Web-Based Homework versus Paper-Based Homework in United Arab Emirates Secondary Mathematics

By

Sean Jenkins

A Dissertation Submitted in Fulfilment

Of the Requirements for the Degree of

Master of Philosophy (Mathematics Education)

Of

University College London

Institute of Education

Department of Curriculum, Pedagogy and Assessment

University College London

March 05, 2021

Abstract

This study investigated whether Web-based homework (WBH) in mathematics is a method of homework delivery more suitable than traditional paper-based homework (PBH) for United Arab Emirates (UAE) secondary students in Abu Dhabi. Few studies have addressed delivery methods for mathematics homework outside of a context where homework is considered usual practice. The study centres in the UAE because of its culturally distinctive attitudes towards homework completion and reportedly low levels of self-efficacy among Emirate students. If homework completion and performance were to increase, WBH could offer opportunities to enrich student learning and engagement in mathematics.

This study used the WBH tools Myimaths and GeoGebra in selected school years. The research questions for this study were as follows: (1) Do students interact more with WBH than with PBH? (2) What are student perceptions of their learning with WBH and PBH? The sample consisted of approximately 2,000 students. The data for this two-group, pre-and post-test control group design was collected over three years, covering school years 2012 to 2015. As a measure of interaction, a Pearson Chi-square test suggested that student homework completion was significantly higher in the WBH group. The result led to the rejection of the null hypothesis for the first research question, suggesting that students do interact more with WBH than with PBH. Analysis of the student survey and interview transcript notes indicated that students perceived they spent more time practicing mathematics using the WBH tools due to the immediate feedback offered by the tools. Furthermore, they were encouraged by the feedback to review their mistakes and revise their thinking, subsequently resubmitting their WBH to get a higher score. Student perceptions in this study were that the availability of multiple homework submissions was a motivating factor that contributed to them spending more time practicing mathematics. Students reattempted the homework tasks that led to the possibility of them revising certain mathematical concepts and procedure while in pursuit of a higher homework score. Though WBH is limited in terms of written explanations and partial credit scores for correct mathematical procedures, in comparison to PBH, student interview perceptions in this study were that the WBH tools used facilitated positive interaction effects. The effects described

were improved levels of motivation, positive peer communication, higher rates of homework completion and an improvement in their mathematics homework performance.

Impact Statement

Title: Web-based Homework versus Paper-Based Homework in United Arab Emirates Secondary Mathematics

Issue: Mathematics homework is often not given in the UAE due to teacher perceptions of the reduced self-efficacy levels of students. If Web-based homework improved levels of homework completion and interaction in this region, imagine the possible impact elsewhere and in less affluent regions worldwide.

What was done: Mathematics Web-based homework was introduced by me as an alternative supplement to traditional paper-based homework to try to stimulate homework completion and interaction.

Impact:

- Study results demonstrated that WBH completion rates were higher than those for traditional PBH
- The study revealed that there is the possibility of blending both modern and traditional forms of educational pedagogy to achieve higher rates of mathematics homework completion and performance
- The introduction of mathematics WBH reported improved communication between students, their peers, parents and class teachers
- Student self-efficacy levels were high throughout the study duration, and there were limited reported accounts of mathematics anxiety
- The analysis of the study and student reports suggested that immediate feedback offered by the WBH tools was the key to students interacting far more with mathematical content material
- Participating students reported that due to the tool's facility for multiple homework submissions, they were able to revise their mathematical thought processes where necessary and resubmit their homework to get a higher mark
- Student perceptions in this study were that they were more motivated to complete mathematics WBH than traditional PBH

- This study identified a need for more professional development training to equip teachers with the necessary skills to support and supplement curriculum content material (in the first instance) with Web-based learning (WBL) and WBH, and this goes beyond the realm of mathematics education.

Dedication

This dissertation is dedicated to my family, especially my wife, who gave me so much help with our children so that I could focus on my passion for education. My family have given a lot of love, encouragement and inspiration throughout this process and in my life, and I love them all.

Acknowledgements

I thank Dr Eirini Geraniou and Professor Candia Morgan, who encouraged me to move forward. I respect and appreciate their efforts to help me to move towards the completion of this study through their emails, Skype calls and face-to-face guidance.

This study would not have been possible without the help and support from my family. My wife and my children were always there to encourage and support me when I was struggling and ready to give up. My daughters offered me inspiration through their support, and my son has always been a guiding influence. Thanks to you all for believing in me. Without your support, this study could not have happened.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ADEC Abu Dhabi Education Council

ADSM Abu Dhabi School Model

AfL Assessment for Learning

ANCOVA Analysis of covariance

ANOVA Analysis of variance

DGS Dynamic geometry software

EMSA External measure of student achievement

GAS Giving Answer Strategy

ICT Information and Communication Technology (see section 5.6)

IoE Institute of Education. (see section 3.9)

ITS Intelligent tutoring system

IWB Interactive whiteboard

IWBL Interactive Web-based learning

KMO Kaiser-Meyer-Olkin test (see section 3.8)

KS Kolmogorov-Smirnov test

MARS Mathematics anxiety rating scale

MCR Missing value analysis (see section 5.5.4)

NELS National Education Longitudinal Study

NSM New school model

OECD Organisation for Economic Cooperation and Development

OWL Online Web Learning (see section 2.3.1)

PAS Prompting Answer Strategy

PBH Paper-based homework

PBUH Peace be upon him

PISA Programme for International Student Assessment

Q-Q Quantile-quantile plots. (see section 4.3)

RQ Research question

SAR Special Administrative Region

SNK Student-Newman-Keuls

SPSS Statistical Package for the Social Sciences

STEM Science, technology, engineering and mathematics

TIMSS International Mathematics and Science Study

WBH Web-based homework

UAE United Arab Emirates

Chapter 1 – Introduction

1.1 Rationale

This study examined whether Web-based homework (WBH) was a more suitable method of homework delivery than that of traditional paper-based homework (PBH) given the context of the United Arab Emirates (UAE). Reportedly, there are low levels of student mathematics homework completion that have been associated with reduced student self-efficacy levels when given traditional mathematics PBH (Sartawi et al., 2012). I hypothesised that by introducing WBH as a supplement or as an alternative to PBH, homework completion rates could improve. In so doing, it was essential to look at the perceptions of students about the WBH tools used over a period in comparison to that of traditional PBH; the study thus covers three years. Particular literature supports the correlation between students' use of WBH tasks and improved scholastic performance (Wooten and Dillard-Eggers, 2016). However, to my knowledge, no clear recommendation has been developed regarding whether these Online tools should be used optionally or made standard in secondary schools as part of a teaching, learning and assessment process. Therefore, further research into the use and efficacy of WBH in comparison with PBH is necessary. Many definitions of WBH exist, but this study regards WBH as an Online technology tool that allows students to solve mathematics homework questions and problems, submit their answers and receive immediate feedback (Bonham, Deardorff and Beichner, 2003; Khanlarian, 2011). Web-based homework is a relatively new phenomenon and, not surprisingly, very little is known about its various characteristics, composition and its impact on student learning over time (Khanlarian, 2011; Nguyen & Kulm, 2005).

The cultural context of this study—the United Arab Emirates (UAE)—is unique. The UAE has pursued an ambitious education programme to encourage and facilitate learning. This program includes substantial investment to supply schools and Emirate households with computer technology and access to the Internet. Understanding the use of WBH tools in little-studied settings such as the UAE are advantageous to the broader academic community. Such an understanding provides insight into how different types of students perceive, interact and behave with technology tools created in more familiar settings (Browne, 2013). Investigations like this can illuminate whether these students' interactions or perceptions differ from those of students in commonly studied settings such as the USA, Europe and the UK.

This research aims to compare WBH with PBH in four United Arab Emirates schools (two schools for boys and two for girls). A two-group control, pre-and post-test design was used to compare homework methods. One group was subject to control (i.e., PBH) and the other, an intervention (i.e., WBH). The intervention group used the WBH tools Myimaths and GeoGebra to mark and grade homework, while the control group had their homework marked by a teacher in the traditional way. Then, student perceptions or attitudes about each homework method were investigated by a survey and follow-up interviews.

1.2 Problem Statement

Mathematics homework completion in some of the UAE, Abu Dhabi Education Council (ADEC) schools was identified as a problem (Clarke, 2016). Clarke found that attitudes towards homework and its completion were not seen as being necessary. The results from a survey of newspaper readers suggested that 80 per cent of those polled were in favour of banning homework. It is challenging for classroom teachers in the UAE to develop a culture of work outside of school hours without the support of most parents (Clarke, 2016). This attitude also goes against the ambitions of the UAE's 2030 vision of creating a competitive world-class education system that promotes, fosters and builds positive attitudes towards learning that could propel the UAE into becoming a more competitive economy (ADEC, 2012).

In 2014/2015, the Organisation for Economic Cooperation and Development (OECD) who are the developers of the Programme for International Student Assessment (PISA) tests, completed a report on homework around the world. It found that 15-year-olds worldwide spent, on average, about five hours per week doing homework. Surprisingly, countries like Finland and Singapore spent less (two to three hours per week) but still had high PISA rankings. Therefore, it concluded that time spent doing homework did not necessarily translate into improved student performance. The authors of the study said that it is the approach that students take towards task completion in and out of school that matters most (Falch, 2011; OECD, 2016).

My hypothesis is that by introducing WBH to students in the UAE, attitudes towards homework and its completion could change. The attitudinal change would allow students to spend enough time on their homework both in and out of school, as the teacher and student can review mathematics content material that supports and supplements the teaching and learning process.

1.3 Research Questions

The main research questions (RQs) were as follows:

1. Do students interact more with WBH than with PBH?
2. What are student perceptions of their learning with WBH and PBH?

Both quantitative and qualitative data were collected. The quantitative data looked at the means and standard deviations of homework scores. Percentages of homework completion rates were compared. The data also comprised of an analysis of a Likert-scale ordering of preferences from a student survey. Also, interviews were used to gain insight into the students' perceptions about their learning with WBH and PBH delivery methods.

1.4 Traditional and Modern Education in the UAE

Historically, the primary source of educational technique in traditional education was that of oral recitation (Bahgat, 1999). A traditional style of teaching and learning has been passed to generations of UAE citizens as a direct result of the teaching and learning of the Qur'an (Aqsha *et al.*, 2011). The traditional teacher told the class how to perform a task, and the students were expected to comply (McDonnell, 2008). This type of unilateral instruction pre-dominated throughout Arabia after the spread of Islam 610 A.D (Aqsha *et al.*, 2011). With traditional education came traditional values based on the teachings of the Qur'an (Aqsha *et al.*, 2011). Religion, language and history were the main focus of education in the UAE until the oil economy emerged in the early 1960s (Bahgat, 1999). At that point, the education system began to focus on modernisation for an expanding global economy that would require the use of technical and vocational skills, as well as academic ability. The region's dependence on foreign labour to fill this gap is evident throughout the Gulf, as governments struggle to develop nationalisation programs to fill these skilled positions with their citizens (Bahgat, 1999).

In an attempt to modernise education and training in the UAE, the constructivist approach to teaching and learning was heavily endorsed by the ADEC in 2006 (Farah and Ridge, 2015). Constructivist educators believe that students learn best when problems are posed to them and that students can learn through exploration and active engagement (McDonnell, 2008). The ADEC believes that while religion, language and history must be preserved to identify Arab culture, it must be complemented with the "proper dose" of science, technology and information (Bahgat, 1999, p. 131). However, issues arise surrounding the free movement of information in this region for fear of instability; the clearest example of this fear is Internet access (ibid). The state communication networks provide the Internet through proxy servers, and content material that is politically, socially and culturally sensitive are automatically blocked (Bahgat, 1999).

A dilemma may arise between preserving a religion, language and a history that is unique in the context of a geographical region's affiliation with what is known as the "Golden Age," a time of great accomplishment in the Islamic World and constructivist teaching principles in education. Islamic and Arab history are incredibly proud of their scientific contributions to civilisation, and this was acknowledged in the Western World by the former president of the United States, Barack Obama, who said:

> "It was Islam that carried the light of learning through so many centuries, paving the way for Europe's Renaissance and Enlightenment. It was innovation in Muslim communities that developed the order of algebra; our magnetic compass and tools of navigation; our mastery of pens and printing; our understanding of how disease spreads and how it can be healed."
>
> (Barack Obama cited in Ofek, 2011, p. 1).

These accomplishments may not commonly feature in Western accounts of world history, but in Islam and to Arabs, this is an integral part of their identity (Ofek, 2011). Arabs who attend school in the geographical region known as Arabia, post–Prophet Mohammed (peace be upon him [PBUH]), are taught this proud historical period in modern-day schools.

"The Golden Age" in Arabia and Africa was referred to as the "Dark Ages" in Europe and the Americas. It spanned approximately the eighth to the 13th centuries A.D., and the disparity of intellectual achievements between then and now in comparison to the rest of the world is of enormous significance (Ofek, 2011). Arabic knowledge thrived at the time, due to Islam being the dominant civilisation in the world (Ofek, 2011). Historical accounts suggest that by 750 A.D., Islam had spread throughout Arabia, Iraq, Syria, Lebanon, Palestine, Egypt, and much of North, East and Central Africa, Central Asia, Spain, and bordered the fringes of China and India. Newly opened routes connecting India and the Eastern Mediterranean encouraged trade and an agricultural revolution (Ofek, 2011). According to Ofek (2011), it was the first time since Alexander the Great that this vast geographical area was united both politically and economically. First arose the Arab kingdom under the Umayyad caliphs (ruling in Damascus from 661 to 750) and an Islamic empire under the Abbasid caliphs (ruling in Baghdad from 751 to 1258). This period witnessed what has been called the most "intellectually productive age in Arab history" (Falagas, Zarkadoulia and Samonis, 2006, p. 1581). The Abbasids Islamic leaders were believed to have followed the teachings of the Prophet (PBUH) and made the search for knowledge a quest (Falagas, Zarkadoulia and Samonis, 2006). Scholars would travel to teach and share ideas, and as a result, Arabic became the universal language of scholastic work. Libraries were established in Cairo, Aleppo and Baghdad with learning centres in Iran, central Asia, and Spain. Bookshops opened with numerous titles on science, mathematics, astronomy and medicine (Ibid). Finally, an academic institution was created that served as a university, *The House of Wisdom* in Baghdad 1004 A.D. (Falagas, Zarkadoulia and Samonis, 2006).

Ironically, the "Golden Age" produced scholarly works across literary fields, even though the predominant forms of teaching required memorisation and rote learning (Falagas, Zarkadoulia and Samonis, 2006). Discovery and exploration were seen for a period in Arab and Islamic history as unlimited and having very few boundaries. Great scholastic works were translated that led to discovery, rediscovery and subsequently, innovation (Falagas, Zarkadoulia and Samonis, 2006). It may seem counter-intuitive then, that certain problems appeared with this teaching and learning methodology in this historic time. According to Ofek, few Arabs could seek education enough to compare with the scholastic work that was going on at the time. This was evident by the length of time it took Arabs and Muslims to use material that they were purported to have discovered. In many respects, such innovative activity did not happen until centuries later, which would be indicative of an elite stratum of scholarly activity (Ofek, 2011).

The UAE wants to maintain its cultural heritage, identity and religious values and Islamic education are at the forefront of this effort in schools (ADEC, 2012). Pedagogy throughout the UAE has barely changed since its introduction into the Kuttub schools (schools children attend to learn the Qur'an). Memorisation and rote learning are essential to the success of memorising the Holy Qur'an (Falagas, Zarkadoulia and Samonis, 2006). However, the ADEC has embraced constructivist learning principles and has implemented a new teaching and learning curriculum from year one to year six. Memorisation and rote learning had become "dirty words"; hence the movement away from drill discipline and practice in the early years of mathematics education (Farah and Ridge, 2015). Students from an early stage in their developmental process were required to try to find relationships between new concepts and their current understanding of certain topics. There is a possible conflict between the reality of how information is disseminated to students and how the ADEC reform process wants students to access information. Students are used to being given the information or told what to learn and how to learn it (Falagas, Zarkadoulia and Samonis, 2006). The didactic (instructor-led) approach to education still pre-dominates in the UAE, due to Qur'anic education and its teaching method. Memorisation, drill and practice are commonplace, with keen students taking on additional practice at home with the support of family members, friends or Islamic scholars within their local communities (Farah and Ridge, 2015). The requirement and expectation for them now to access the information themselves, be able to evaluate it, process it, and critically analyse it maybe too high, given the societal and cultural make-up of the UAE. This study tried to address this dilemma with the use of the tools Myimaths and GeoGebra. Myimaths requires discipline and practice that is associated with the didactic style of teaching and learning as it is referred to as an 'Online' textbook (Watershed, 2011). However, GeoGebra, with its ability to get students to interact more with its tool features and be more creative about how and what students learn facilitated the ADEC goals surrounding constructivist learning and its principles. Both tools were used in this study to meet the criteria as to what constituted WBH. However, the GeoGebra tool was adapted by being uploaded to the www.classtell.com website for ease of student access with a passcode. It also had to be adapted for the provision of immediate feedback. The idea behind this approach was that if the "Golden Age" could produce innovative and constructivist work despite the Qur'anic, didactic education given, types of learning theories could be embraced to facilitate the achievement of set goals.

In 2010, the new school model was introduced as part of a reform process that aimed to focus on a child-centred approach to learning that encourages learner autonomy and critical thinking (ADEC, 2012). The new school model claimed to embed professional development for teachers and school leaders as an integral part of its educational reform process. Therefore, it was sensible to use Myimaths as being compatible with the traditional approach to learning and GeoGebra as being compatible with the ADEC reform agenda. The use of the tools Myimaths and GeoGebra in this study can be argued to fit into different forms of learning categories even though they come under the heading of Web-based Learning (WBL). As mentioned earlier, Myimaths is regarded as an Online textbook that encourages rigorous mathematical problem solving through practice and repetition. Arguably, it fits into an *objectivist* approach to learning (Carter and Norton, 2013). This epistemology espouses that the laws governing mathematics, are to a large extent constant, although our knowledge of them may evolve (Nathan and Scobell, 2012). The Online textbook from Myimaths presents a body of knowledge to be learned, and this knowledge is in the form of considered facts, formulas, terminology, principles and theories (Watershed, 2011). GeoGebra allows students to construct interactive representations of points, lines, and circles. The construction of these geometric objects are interactive, and the student can reshape, resize and move them around the screen by using clicking and dragging tool features. GeoGebra arguably fits into the *constructivist* approach to learning (Gergelitsov´a, 2014; Gergelitsová and Holan, 2016). This approach suggests that students construct knowledge, meaning and understanding of events based on their individual and shared experiences (Piaget, 2013). GeoGebra facilitates and encourages students to reflect, evaluate their work, and to be able to identify any intermediary skills that are needed in order to complete set tasks (Saha, Ayub and Tarmizi, 2010). It seemed appropriate to use GeoGebra in this study as it fits the reform agenda and promoted teacher development and student exploration. It also facilitated social interaction, so learners interacted with their peers to share the knowledge that helped them to achieve specific learning goals or targets. The cognitive aspect of learning was achieved through visual representations of the tool's features, which assisted both the teacher and student in learning mathematics and accorded with the principles of constructivist learning (Garelick, 2005; Praveen and Leong, 2013).

1.5 United Arab Emirates Education Reform

Education reform in the UAE (The Road to 2030) has six main priorities. The first is to elevate the quality of schools in Abu Dhabi against international standards. The second is to improve access to education for all Emirates from the primary school level through to grade 12. Third, is to provide affordable options for high-quality private education. Fourth, is to preserve UAE culture and heritage and to develop successful careers for students to pursue. The last two final points are to do with improving the capabilities of the ADEC and actively seeking to engage stakeholders (ADEC, 2012). The reform is aimed at addressing every component of the education system to improve the capabilities of school leaders and teachers. The ADEC intention is to upgrade the curriculum to meet the emerging socio-economic requirements by trying to implement an ambitious students assessment system based on local and international standards. Also, ADEC wants to implement a comprehensive school monitoring and inspection system for public and private schools and to upgrade the public schools' facilities, while at the same time attracting and expanding the use of quality private schools. ADEC also aims to target special needs education and to raise the curriculum standards for Arabic, Islamic studies and civics (ADEC, 2012).

The effectiveness of traditional education and its knowledge transmission was questioned when the ADEC looked at educational reform and started to recruit teachers from Western countries. The ADEC was used to help foster the vision (2030) of moving the UAE from an oil and gas revenue dependent country into a more diverse international competitive market economy (ADEC, 2012). Western teachers were recruited on the basis that they were familiar with constructivist teaching principles and would be able to relate problems to everyday mathematical solutions. The teacher's ability to seek and to value the students' points of view; devise activities that challenge student assumptions; pose mathematical problems of relevance; build lessons around big ideas and assess learning in the context of daily teaching is considered to be core elements of the principles of constructivist teaching (Abida and Muhammad, 2012; Piaget, 2013). Teachers were encouraged to use tools, mathematics manipulatives and computer technology over textbooks. This approach to learning was based on research suggesting that students can construct their own knowledge instead of attaining it passively from their teachers (Murray *et al.*, 2006; Quirk, 2012).

Education reform in the UAE adopted a policy approach to setting homework at least once a week in government schools. It was believed that setting homework would improve levels of self-efficacy that involved organisational ability and time management, believed to be the necessary social skills required to compete in competitive environments (ADEC, 2012). "The road to 2030" refers to the UAE's vision of education reform, stating the government of Abu Dhabi's desired objectives and approaches to learning; however, homework itself is not mentioned. There is the mention of "improvement imperatives" to foster self-efficacy and independent learning, with the belief that such imperatives will help the UAE's education system to compete internationally (ADEC, 2012, p. 3). This has led the UAE to participate in external assessment examinations such as the Programme for International Student Assessment (PISA) and The International Mathematics and Science Study (TIMSS). It is anticipated that their performance results would be a measure of how they were doing with the reform process and how far they would have to go to reach associated international standards and their benchmarks.

1.6 Learning Theories

Given the contextual nature of this study, is set in the UAE, it is essential to draw attention to the identified scholastic methods that are used to enhance learning. A possible dilemma or conflict has been identified in this study between the traditional approach to teaching that has come from Qur'anic education and the "2030" vision endorsed by the government of the UAE.

Historically, contemporary educational theory recognises that behaviourism was at the forefront of this developmental learning continuum (Sadowski, 2009). Behaviourism has been described as a theory of learning that primarily focuses on observable behaviours and takes away any independent activities of the mind (Bower and Hilgard, 1981). Behaviour theorists often define learning as the acquisition of new behaviour based on environmental conditions. Skinner (1950) described this as "a change in probability of response" (Skinner, 1950, p. 193). Skinner felt that behaviourism presented an environment that trained the student to work or perform. Experiments conducted by behaviourists lead to suggestions that conditioning was a universal learning process and that two types of conditioning produced different behavioural patterns. The first, referred to as classic conditioning was when a natural reflex responds to a stimulus. The typical example given is where students exhibit emotions such as fear, anxiety or develop a phobia about failure. In an educational setting, this is usually a general school phobia about the fear of being unsuccessful at a given task. The second example is that of behavioural conditioning. Behavioural conditioning is where a response to a stimulus is reinforced by regular or continuous feedback. This form of conditioning could be associated with the teaching and learning of the Holy Qur'an. It was also felt that if reinforcement followed the response to the stimulus, the same exhibited procedures could probably be repeated more often in the future. Skinner (1950) used this technique of reinforcement and continuous repetition to get pigeons to dance and bowl a ball in a mini alley. This form of conditioning is useful in getting students to re-attempt work that has been marked incorrect. This form of engagement in an attempt, re-attempt cycle could prove to be a beneficial pedagogical approach to learning mathematical procedures (Zerr, 2007).

Theorists of learning that talk about the use of mental representations of certain phenomena are called cognitivists (Amuthabala, 2014). Cognitivists are associated with a theory of learning that believes people develop mental representations of the world and that they act based on these representations. These representations can be encountered in new situations where pre-existing models of the world can be assimilated to suit new situations (Mayer and Sims, 1994). According to cognitivist theorists, mental representations can be expanded to make them more accurate, and this distinguishes itself from other theories by producing a genuine understanding of a topic instead of just producing the right behaviour. In mathematics education, this would be the ability of a student to attain the correct answer or solution to a problem without understanding what it was they had found (Mayer and Moreno, 2003). Cognitivists believe that the student is a unique organism and has a view of worldly events that are different from others and that information is processed according to their distinct perspective.

Constructivism is a theory of learning that says students best learn by building upon their previous knowledge or understanding of any given situation (Bruner, 1985). If that situation has not been encountered, then the student constructs and develops their understanding based on their knowledge of events. Constructivism is applicable to any discipline, but it is vital to the context of this study. Students in the UAE have had years of drill discipline and practice as a result of the Qur'anic teaching style in the Kuttub schools. The constructivist teaching methodology the ADEC has embarked upon tries to remove the role of instructor-led teaching. This is when the teacher is the driver, lecturer and disseminator of mathematical information and knowledge. Therefore, situations would now have to be created for students that would allow them to foster and grow mental mathematical constructions by finding relationships between new topics and their current understanding of a topic (Piaget, 2013). This study is different in the sense that it tried to embrace both the traditional and modern elements of the learning theories. It does this by using the traditional PBH and comparing it with WBH tools that can be considered as behaviourist (Myimaths) and constructivist (GeoGebra) in their application. The tools are discussed in the review of the literature in chapter 2.

1.7 Predicted Outcomes

This research highlights an important gap in the knowledge surrounding WBH and PBH completion rates in the UAE and what was done to try to improve homework completion and performance. Finally, student perceptions were used to gain an understanding of their experiences with the homework delivery methods and whether their accounts would support or reject this study's hypotheses.

1.8 Summary

This study tried to find out if WBH was a more suitable method of homework delivery given the identified problem in the UAE with secondary students and their lack of mathematics homework completion. A possible solution to the problem was introduced to try to improve rates of mathematics homework completion and performance.

The rationale, which included the background to student learning in the UAE and the problems associated with the prevention of mathematics homework completion was introduced to the reader in order to establish an understanding of the variables that could affect mathematics homework completion.

In the next chapter, the review of the literature on WBH looked at possible constructs that could affect homework completion and student performance, as a student attempts to complete the assigned homework task. I started with the construct of homework itself and whether it is suitable in the context of the UAE. The critical role that feedback plays is also reviewed as it is highlighted as one of the most important features in WBH studies (Bonham, Deardorff and Beichner, 2003; Mavrikis & Maciocia, 2003; Khanlarian, 2011). The construct of student self-efficacy levels and the role it uses to assist students with their homework completion is also reviewed along with the possibility of mathematics homework anxiety. The constructs of motivation; the suitability of the technology and metacognition, where the student can revise and review strategies to answer questions due to the availability of instant feedback and multiple homework submissions were also investigated. Finally, the construct of support which includes, parental involvement, peer support, help features and methods of communication that could facilitate homework completion, is also addressed. It is important to note that student mathematics homework performance can vary considerably and is certainly not limited to the constructs mentioned in chapter two. However, the constructs do offer some insight into how the students' attempted homework completion and how their performance can be affected in different ways.

Chapter 2 – Literature Review

2.1 Introduction

This literature review starts by examining the existing knowledge that is already in the field of WBH versus PBH studies. Several studies have examined the use of WBH in comparison to that of PBH. However, few have attained a result beyond that of equivalence. The results suggest that WBH is at the very least, as effective as PBH. Studies have been conducted on the use of WBH in physics (Dufresne *et al.*, 2002; Bonham, Deardorff and Beichner, 2003; Pascarella, 2004; Toback, Mershin and Novikova, 2005) and mathematics courses (Hirsch and Weibel, 2003; Bliwise, 2005; Zerr, 2007; Hauk, Powers and Segalla, 2015). Also, research was completed on other studies that looked comparatively at WBH and PBH in order to address the problem that was specific to the context of the UAE (Khanlarian, 2011; Locklear, 2013; Nguyen & Kulm, 2005). Primarily, this problem was the lack of homework completion, but the study does look at some of the variables that could affect homework completion and performance. This research tried to provide a solution to the problem of homework completion by offering WBH as an alternative or supplement to PBH whilst seeking information on student performance and their perceptions of both homework delivery methods.

2.2 Mathematics Web-based Homework

One of the earliest studies that addressed any kind of definition of Web-based homework (WBH) was that of Bonham et al. (2003), who wrote:

> "In a typical Web-based homework system, students log on using a password through the Internet to a central Web server, select one or more assignments, and receive those exercises" (Bonham, Deardorff and Beichner, 2003, p. 1053).

In addition, Bonham describes that in many cases, the numerical exercises given to students are algorithmically scrambled, so that each student is assigned a different set of numbers. Once the student has attained an answer, it is then submitted and, in most cases, the tool will immediately evaluate the answer. This answer provides the student with some level of feedback that "may allow reworking and resubmission of the assignment depending on how the instructor has set options" (Bonham, Deardorff and Beichner, 2003, p. 1053). The instructor can then handle the administrative details or create new assignments and questions, and review or download student scores and responses. Bonham (2003) also acknowledged that some WBH tools had additional support features such as chat rooms, instructor notes and calendars that he claimed "added to the experience of the learning process" (Bonham, Deardorff and Beichner, 2003, p. 1053).

When students use WBH, the feedback given in most cases to them can be considered behaviourist in its approach, as there are very few suggestions as to how to move forward. However, due to the immediacy of the feedback, cognitivist thought processes can occur, and in some cases, they are encouraged (Khanlarian, 2011). This process can lead the student to find the link between a new concept and their current understanding of a topic. Certain types of technological tools can both facilitate academic advancement in the classroom and promote more cohesive homework assignments that allow students to practice "…specific skills of a complex process" (Parmigiani, 2012, p. 195). According to Pitler et al. (2007), at the very least, the student can become a problem solver, with the possibility of concepts becoming clear later. It is, therefore, possible for a learning continuum to evolve with the use of WBH that could help to bridge the gap between traditionalist teaching methodologies and constructivist learning principles adopted in the UAE. Not only can the WBH element reinforce teaching and learning objectives, but also it can facilitate the development of independent learners. It is important to note that in the Bonham et al. (2003) study that compared student WBH with PBH performance over several years where there were a total of 117 students (35 women) in the WBH section and 113 students (20 women) in the PBH section; they found no significant difference between homework delivery methods. They concluded that WBH is at least as effective as PBH.

Several studies have compared WBH with traditional PBH (Dufresne *et al.*, 2002; Tang and Titus, 2002; Bonham, Deardorff and Beichner, 2003; Mavrikis & Maciocia, 2003; Pascarella, 2004). However, the vast majority of these mathematics studies were conducted at the college and undergraduate level in the United States. These studies have centred on mathematics courses that examined the effects of WBH systems on calculus, finite mathematics and algebra. The Web-based Online systems used allows for multiple-choice and open-response items with the provision of immediate scoring and feedback. Some homework systems allow students' multiple attempts per question or test, as well as provide hints and examples for problem-solving. The results of these studies have been mixed, with some studies suggesting that WBH increases student performance as indicated by test scores (Porter and Riley, 1996; Dufresne *et al.*, 2002; Hirsch and Weibel, 2003; Larose, 2010). Other studies indicated no significant differences between the WBH and PBH delivery methods used and concluded that WBH is at least as effective in terms of performance as PBH (Bonham, Deardorff and Beichner, 2003; Kodippili and Senaratne, 2008; Palocsay and Stevens, 2008; Hauk, Powers and Segalla, 2015)

Chronologically, one of the first reported studies to offer any comparison between WBH and PBH was that of Porter and Riley (1996) in the United States. Porter and Riley used two sections of an introductory statistics course that was taught by the same instructor for the study. The first section used traditional PBH, and the second used a WBH program created by the instructor. The study compared exam scores between the two sections. Porter and Riley found that students who used WBH scored an average of 20 points more on homework-related exam questions. Students were able to get worked solutions to all problems that were answered incorrectly, and there were no restrictions on the number of attempts of the adapted WBH question. The WBH group did have to complete more questions than the control PBH group, which could have led to better homework scores. However, there was no significant difference reported between the groups. Even though the WBH and PBH group performances were compared with exam related questions, the overall performance of the groups was in favour of the PBH group that reportedly scored slightly better given all homework questions. No indication was given as to why this result may have occurred. The study concluded that WBH had a positive effect on student achievement (Porter and Riley, 1996).

Dufrense et al. (2002), found that WBH leads to higher overall exam performance. Their study was conducted using an Online Web-based Learning system called OWL. OWL was used at a large public university in the northeast of the United States. Their research found that students in the introductory physics courses using OWL to submit assigned homework tasks and receive feedback, received significantly higher marks on their course exams. This group was contrasted with control-group students who submitted their homework via traditional methods using paper and pencil. Dufresne et al. (2002) compared the performances of students over several years. These students studied in calculus and algebra-based courses with four different instructors who had taught courses with both PBH and WBH systems. Dufrense et al. (2002) found that student exam scores improved significantly after the introduction of WBH. Students who used WBH were reported to spend significantly more time on their assignments than those using PBH. A substantial factor considered for improvement was the provision of immediate feedback to students. Students reported that they would use the feedback to adjust their problem-solving strategies to try to get the correct answer and then resubmit their work. Even though the feedback was limited to hint and help features and the provision of right and wrong answers, the students reported that they could adjust their schema to find the correct solutions. Replacing PBH with WBH was found to produce better exam scores in physics and mathematics (Dufresne *et al.*, 2002). The performance differential indicated in the study was around "a third of a typical exam standard deviation for a given class" (Dufresne *et al.*, 2002, p. 247). A statistically significant difference was established in a course taught by one of the four professors teaching, where a part of the final examination mark reflected the same core elements across three different parts of the same course. Their findings showed, to some extent that students who do well on their homework generally receive higher exam results (Dufresne *et al.*, 2002). However, it must be noted that no evidence of a differential impact was found when PBH replaced WBH. The study concluded that performance in WBH and PBH groups was "similar for low and high SAT mathematics groups, for low and high homework score groups, and low and high exam performance groups" (Dufresne *et al.*, 2002, p. 247).

Tang and Titus (2003) used what they considered to be well-structured questions to evaluate the perceptions of students in North Carolina (USA) regarding the use of WebAssign to mark and grade calculus and physics homework. This approach was an attempt to present using a WBH management delivery system that encouraged active-engagement assignments in Calculus and General Physics. Their aim was also to increase students' time on tasks outside the classroom. They found that student interaction with faculty and peers increased, as did the amount of time spent on coursework outside the classroom, enabling faculty members to concentrate on the course, based on immediate feedback (Tang and Titus, 2002). The study used WebAssign as a vehicle to try to engage students in the learning process and to stimulate their learning efforts in calculus and physics and to improve their performance. The study noted that weekly homework assignments and quizzes that were delivered, collected and graded through WebAssign: "increased students' time and effort; generated appropriate learning activities such as interactive and cooperative learning;

increased contact between students and faculty; increased reciprocity and cooperation among students; provided prompt feedback to students and enabled the instructor to pay attention to what students do in order to learn" (Tang and Titus, 2002, p.15). Twenty-three students from a Calculus I class supported the observations and 147 students from two General Physics I classes. Their support was offered in a student opinion survey on the use of WebAssign to improve overall student interaction and performance. The study concluded that well-designed problems given and marked by the WBH tool WebAssign represented clear favourites over PBH.

Hirsh and Weibel (2003) compared the performance of university students in the United States using WBH and traditional PBH in their general calculus classes. They found that students who used WBH had a small, but statistically significant improvement in their final exam score. Hirsh and Weibel believed that the exam score gains could have been far more significant if it were not for the small number of students assigned to the treatment (WBH) group. This encouraged them to do a within treatment group comparison with students who completed the majority of their WBH tasks with those who completed just a few or none. A very high correlation was found between the number of problems attempted and the number of correct solutions. This suggested to the researchers that students persisted with their mathematics WBH problems until they got the correct solutions and improved their mathematics performance. Since students were allowed multiple attempts at solving WBH problems, it was perceived as a positive attribute of student effort as opposed to their levels of ability (Hirsch and Weibel, 2003).

Hauk and Segalla (2005), investigated differences in mathematics achievement in college algebra courses, between undergraduates using WeBWork, an open-source WBH system and traditional PBH. The study assessed learning for 439 students in 19 college algebra classes in the United States, where 12 classes used WeBWork and seven classes had the traditional PBH. The analysis of covariance (joint variability of two random variables) revealed that there was no significant difference in algebra performance or achievement gain by homework group, ethnicity, or gender. However, their results supported the notion that WeBWork was at least as effective as traditional PBH given to students. The WBH tool WeBWork provided immediate feedback to students on their answers in the form of "correct" or "incorrect". The WeBWork interface did not provide students with help features and hints; it only lets the user know whether they had attained the correct answer or not. Students could resubmit their answer if incorrect, and the tool was able to algorithmically scramble the problems that were marked wrong so that they were similar in content and procedure, but numbers were different. The students in this study were encouraged by their teachers to seek help from their peers and their teacher when they got stuck on a problem. They were able to do this in person, by email or other communicative methods built into the WeBWork interface or outside of it. The data gathered for the study included pre-and post-test scores, demographic information, and course completion information. The study used a 25-item multiple-choice PBH test that was administered in the first and the last week of a term. The same test was used on both occasions, and students registered their choices on a scannable answer sheet. For the WBH group, WeBWork was able to store information on what questions were attempted, how often and to what level. The study noted that the implementation of homework in college algebra courses in the United States traditionally focussed on factual and assimilative knowledge with very few non-routine problems that encouraged students to be resilient with difficult concepts on their own outside of the classroom (Hauk and Segalla, 2005).

Nonetheless, for students to now have immediate access to this factual knowledge via a WBH tool could help to build, grow and construct conceptual understanding that could find solutions to more complex mathematical problems. According to Von Glasserfeld (2001), constructing concepts encourages a culture of reflection that enables the students to become aware of connections that could link procedures and content material. This theory could be applied to help improve the connections between the understanding of mathematical procedural steps and a topic. The freeing-up of instructor-based time could also facilitate improved student performance as the instructor could focus more on the setting of realistic targets to help their students' move on and to develop even stronger perceptions about their learning. The limitation highlighted in the study was that no socio-economic classification data were collected. However, the phenomenological study did investigate a proxy measure: student access to and comfort with computers, the internet, and Web-based software.

Demirci (2007) tried to determine Turkish university students' perceptions from a 21-item survey regarding WBH and PBH testing. The 21 items were arranged to form a Likert-type scale with a five-point spread. Participant scoring options were (1) strongly agree, (2) agree, (3) no opinion, (4) disagree, and (5) strongly disagree. In addition, the Demirci (2007) study wanted to find if there was a statistically significant difference in students' homework performance scores and physics grade point average scores. The results of the study that was administered to 103 students (54 were male, and 49 were female) in general physics-1 classes suggested that the students' perception about WBH and PBH was found to be positive. Students' perceptions ranged from a mean high of 4.61 (indicating agreement) for the Web-based item "The Online test and its direction were easy to use and read on a computer screen, and the testing was user friendly" to a low of 2.68 (indicating disagreement) for the item "The way in which evaluation of the Online homework scares me" (Demirci, 2010, p. 31). Of the 21-item statements, thirteen (61.9 %) had means between 3.31 and 4.61; eight (38.1 %) had means between 2.51 and 3.30. Also, students' perceptions ranged from a mean high of 4.02 for the item of PBH, "The way in which using grouped pencil and paper homework for this course is appropriate" to a low of 2.81 (indicating disagreement) for the item "The way in which evaluation of the paper and pencil homework scares me" (Demirci, 2010, p. 31). Of the 21 statements, fifteen (71.4%) had means between 3.31 and 4.10; six (28.6 %) had means between 2.51 and 3.30. Concerning student performance, the study did not offer any conclusive reasons as to why students performed better in the PBH group than in the WBH group. However, it said that several studies in addition to that of its own found no difference in student performances when WBH and PBH were compared (Alexander, Bartlett, Truell, & Ouwenga, 2001; Bicanich, Slivinski, Hardwicke, & Kapes, 1997; Bonham et al., 2003). Secondly, it also said that while students' perceptions of Web-based testing were positive, in some areas physics educators may have to adapt the Online testing process to fit the desires of students better so that they could improve on their performance (Demirci, 2007). Students in the study felt that this could be achieved by scaffolding the questions so that students could somehow build on their previous knowledge or understanding of the topic.

Perhaps, more specific to this study, an Online homework system was created for calculus students at the University of North Dakota that also used WebWork. WebWork was used by Hauk & Segalla (2005), as mentioned earlier. However, Zerr (2007), found that using WebWork for WBH material content that was created by the professor on Blackboard to support student engagement outside of the class by trying to replicate the attempt-feedback, re-attempt cycle, significantly improved student test scores. Furthermore, the study suggested that student survey responses indicated a high level of satisfaction with the Web-based homework's usefulness in helping students to understand first-semester calculus concepts. The use of Blackboard to assign student homework and to provide immediate and more detailed feedback to students distinguished itself from the Hauk & Segalla (2005) study as the feedback given in it was limited to correct or incorrect. The use of Blackboard was able to follow-up with the student on their procedural steps used and it provided additional attempts to solve similar problems to engage the student in a re-attempt cycle immediately after reporting their result on the WBH questions that were attempted. Before the due date, students were allowed to retake their assignments as many times as they liked as it was felt that this would provide them with the ability to "learn from and correct any mistakes that they had made on an earlier attempt" (Zerr, 2007, p. 60). It is important to note that since each re-attempt question was generated at random because the questions were scrambled algorithmically, each assignment given would be different from those that preceded it. The study reported that students learnt from their prior mistakes in order to be more successful in their pursuit for a higher homework score and improved performance. The last homework attempted by the student was recorded, and it constituted 10% of the student's final semester grade.

Dillard-Eggars et al. (2008) found evidence that WBH used for accounting classes increased student performance and that students believed that using WBH is an effective method of study. The study gathered data to determine the amount of WBH that was completed and its possible effects on class performance. Two-hundred and thirty-three students were surveyed in eight accounting principles classes that were taught by four different instructors. In all these classes' students had access to WBH problems. For 149 of the students, WBH was a required part of the course grade. In the other classes' homework problems were selected for exam preparation, and their homework was not a separate requirement for the student's grade. Information regarding the amount of completed homework was compiled within the WBH tool. The study was able to link the students who wrote their names on the survey to their homework and course grade. These students were asked about their perceptions of WBH. Their response was mapped on a Likert scale order of preference using open-ended questions. Student responses to the open-ended questions suggested that they liked the immediacy of feedback the tool provided and that the homework was interactive, and it provided help and hints when their first answer was marked incorrect. Students found that typing was more comfortable instead of writing and that WBH provided more structure to problem-solving as they felt that by sitting down in front of the computer was more motivational than sitting with just pencil and paper (Dillard-Eggers *et al.*, 2008). The most commonly cited problem in the Wooten & Dillard-Eggars (2008) study was that students faced confusion with the answer format with their WBH. Students expressed dissatisfaction with their effort to answer questions completely with the correct calculations throughout a process, but when entering the answer, a syntax error was made, and this gave them a lower score. They also expressed their dislike for help features that were to them unhelpful. Some students experienced technical problems while other students felt that some of the assigned problems were too simple or not representative of the complexity of the topic they had covered. Students also noted that there were programme error inconsistencies between the WBH given and their class supporting notes. Some students simply stated that they preferred PBH to WBH.

Kodippili and Senaratne (2008) used a textbook style WBH product (MyMathLab) that provides instant feedback on correct or incorrect solutions, gives access to lessons, help features, and students are allowed multiple homework attempts of the same problems that are scrambled algorithmically. The purpose of their study was to see if the use of MyMathLab would lead to an increase in student performance compared with traditional PBH. Seventy-two students took part in the study. The students enrolled were on a college algebra course in the United States. Results from the study suggested that there was not enough evidence to support that students in the WBH group that used MyMathLab performed better than the students in the PBH group that had their work marked traditionally by an instructor. However, the success rate of the students', indicated by their final grade A, B or C was 70% in the WBH group, while the success rate in the PBH group was 49%. The researchers felt that the difference between homework delivery methods and the success rate of student mathematics homework performance should call for further research with larger sample sizes (Kodippili and Senaratne, 2008).

Brewer (2009) also used MyMathLab in a quasi-experimental pre-test, post-test design in the United States that had five control (PBH) and four treatment (WBH) sections with seven different instructors. When comparing the two homework groups (WBH versus PBH), no significant differences between the groups were found. Mathematics self-efficacy was measured in this study by using a survey design that elicited specific traits associated with self-efficacy. The survey was given at the beginning and the end of a trimester. Again, no statistically significant difference was found between the WBH and PBH groups. The studies concluded that WBH was at least as effective as PBH (Brewer, 2009).

Hodge et al. (2009) conducted a study on the effectiveness of WBH that used homework completion and performance scores as part of its measure for effectiveness with 1,394 college algebra students in the United States. The study found that the correlations and related variance suggested that students who already possessed effective study habits and learning strategies were more likely to view their WBH as being beneficial to them. This was especially true for students who received low scores on traditional PBH tasks that were given; it indicated they were able to identify when they needed help and to whom to go to for assistance. This was also true for students who believed that their own efforts would have positive results (e.g., completing homework would help them learn). The data indicated that students were motivated to complete more homework using the Web-based tool but would prefer not all homework be set up in this manner (Hodge et al., 2009). Besides, it would not deter them from taking future courses using the same or a similar Web-based tool. The results of the experiment showed that students preferred to complete their homework using the Web-based tool (Hodge et al., 2009). To answer their first research question (RQ)— "Would WBH increase the student understanding of mathematics?"—a multiple regression analysis was used to examine the causal relationship between students' perception of using WBH in comparison to their perceptions of PBH (dependent variable). The independent variables used were "methods of expected course grade, previous use of WBH in mathematics, ease of navigation of the WBH tool, the frequency with which homework was completed, and demographic items" (Hodge et al., 2009, p. 621). The demographic data included age, ethnicity, gender, previously taken course, and the students' academic level. They did not find any violations with the assumptions of normality, linearity, and homoscedasticity of residuals (Hodge et al., 2009). The results of their regression model were found to be statistically significant, $F(24, 1051) = 38.953$, $p < .001$. The multiple correlation coefficient was 0.686, which may indicate that 47% of the total variance of "increased mathematical understanding" could be attributable to the perceptions of students' (Hodge et al., 2009, p. 247). The results of the study suggested that the students were motivated to complete more homework using the WBH tool than with traditional PBH methods. Also, about a third of the students surveyed perceived that WBH did increase their mathematical understanding more so than with traditional PBH methods. They also found that students who perceived that they were more motivated to complete their homework using the WBH system, "were also more likely to acknowledge the need for help and seek out assistance from others" (Hodge et al., 2009, p. 618).

LaRose (2010) used WBH as a replacement for ungraded PBH in a Calculus II course at the University of Michigan (USA). The study investigated what impact WBH had on student performance, behaviour and their attitude in completing the assigned tasks. The study found that students in the WBH group appear to do no worse than those in the PBH group and may do better. They noticed that the introduction of WBH in the course grade appears to increase students' attention to the homework being set. Besides, there was supporting evidence that suggested the more considerable attention resulted in students having a better understanding of what they were doing on the homework and the derived benefits they gained by completing it. There was also evidence to support greater instructor flexibility in the management of class time due to the immediacy of feedback and marking the WBH tool provided (Larose, 2010). Twenty-four sections of the Calculus II were randomly divided into three groups of eight sections. The first group completed their PBH assignments that were neither handed in nor graded, the second group completed the same problems for their WBH, and the computer corrected it, but the scores did not count. The third group did the same WBH, but their scores contributed to 5% of the total course grade. The students who completed the assigned WBH tasks performed better, but it was only statistically significant for one assigned task. LaRose (2010) concluded that the most important contributory factor that influences student performance is whether the homework is marked on time and not the method of homework delivery (WBH versus PBH). Also, it was noticed that when the homework counted towards the final grade, students homework completion increased significantly (Larose, 2010).

In a longitudinal study that examined various factors that are inherent in WBH and their impact on student performance on an introductory accounting course in North Carolina, Khanlarian (2010), found that theory driven concepts could be used to explore factors that influence student performance in WBH. The Khanlarian (2010) model was based on student survey responses over three time periods in a semester. His results revealed that the important factors associated with WBH could be listed as: mastery motives, engagement, locus of control, performance goals, self-efficacy, technical efficacy, usefulness, lazy user, frustration, cooperative learning, perceived ability, and the student's grade point average (GPA). Mastery motives are goals that involve a desire to achieve and to demonstrate academic competence, understanding or improved performance using self-established standards (Dowson and Mcinerney, 2004). In the Khanlarian (2010) study, mastery goals were associated with the students' perception that WBH helped them to achieve their primary goal, which was to understand the major concepts and to acquire new knowledge. Mastery motives were different from performance goals because, with performance goals, students wanted to outperform their peers or attain the highest grade possible that was associated with sound academic performance (Dowson and Mcinerney, 2004). According to Dowson and Mcinerney (2004), mastery motives and performance goals have a direct influence on the quantity and quality of the student's focus on learning. Simon (1967) believed that motivation is the impetus behind students setting personal goals and that motives are what causes the student to act in a certain way and that this behaviour had a direct effect on the quantity and quality of student engagement (Simon, 1967). Based on educational theory, according to Simon (1967), and later supported by Greene & Miller (1996), mastery goals are associated with the student's perceived ability to interact meaningfully with their homework. They felt that this could lead to better cognitive engagement, improved levels of self-efficacy and performance (Simon, 1967; Greene and Miller, 1996).

Bandura (1974) described self-efficacy as a person's belief that they can behave in a way that will allow them to achieve their goals. Greene and Miller (1996) found some evidence to support a connection between self-efficacy and the achievement of student mastery goals. This evidence came from student survey responses to items such as: "I can complete homework assignments successfully, and when I work accounting problems using the WBH software, I can get the right answers" (Greene and Miller, 1996, p. 185).

Rotter (1954, 1966) researched the 'locus of control' which was defined as a perception or belief that a person has in their ability to control or have no control over the events that occur in their life. Similarly, an external locus of control is the perception or belief that others and other factors have more control over one's life. An internal locus of control is where every individual can exert some form of control over the events that happen in their lives. Rotter (1966), found that an external locus of control in children was predictive of achievement, but was not as successful in predicting outcomes as children aged (Rotter, 1966; Smith, Trompenaars, & Dugan, 1995). Rotter required students to respond to survey item statements such as, "Chance or luck plays an important part in my success," "Becoming a success is a matter of hard work and that luck has little or nothing to do with it." Also, the statement item "I am able to finish my homework assignments by deadlines was at that time also included" (Rotter, 1966, pp. 11–12). Rotter's scale was later adapted and used by Khanlarian (2010) to suit survey items in his study on attaining student perceptions of WBH.

The technical-efficacy construct that was used by Khanlarian (2010) can be linked to student self-efficacy levels, and it refers to the student's ability, confidence and resilience in overcoming technical difficulties. Low technical-efficacy was associated with high dropout rates and homework incompletion (Sitzmann *et al.*, 2008). Technical-efficacy items that are associated with WBH are that the student tried to discover new functions when using the WBH software (calculator, hints, additional features). If the student heard about a new form of information technology, they would be open-minded and look for ways to experiment with it. Students also expressed their belief that using a computer is an efficient way for them to learn new things (Santhanam, Sasidharan and Webster, 2008; Sitzmann *et al.*, 2008).

The usefulness of technology is an important construct when researching aspects of technology tool usage and the possible benefits for students. Santhanam et al. (2008) studied self-regulatory learning and found that three key factors work together to assist and possibly increase learning outcomes. These factors are information technology, instructional strategy and the learners' psychological processes. The study also found how the students learn, their levels of computer self-efficacy and the level of positive feedback given by the tool or their respective class teacher influenced their learning outcomes. The students' perceptions about the usefulness of the technology tools they are using is a construct worthy of consideration. Based on theories of technology and technology usage, it is fair to think that anyone who engages in technology usage would be subjected to the probability that they would benefit from increased performance (Brown *et al.*, 2002). Brown et al. (2002) researched mandated technology usage in the banking industry and found that workers responded positively to survey items "[the software] enables me to accomplish tasks more quickly," "[the software] has improved the quality of the work I do," and "[the software] gives me greater control over my job" (Brown *et al.*, 2002, p. 295). These statement items were also adapted for use in the Khanlarian (2010) study to fit a technology usefulness construct. These survey construct items were: using WBH software enables me to finish the homework assignment faster than PBH; WBH software has improved the quality of the work I do compared to PBH, and WBH software gives me greater control over my work compared to PBH (Brown *et al.*, 2002; Khanlarian, 2011).

The Khanlarian (2010) study concluded that the data collected on student survey perceptions demonstrated acceptable Cronbach alpha scores. All alpha scores on the constructs that were used that fell below 0.6 were dropped. The data were also used in a principal components analysis to test for survey structure and development, and several models (rotational) were used. The resultant confirmatory factor analysis supported the constructs that were employed. The study found that there was a distinct change in student behaviour over the three-time periods. This change in behaviour was attributed to the students' mastery motives that they said was a strong predictor of student engagement, self-efficacy, technical efficacy and usefulness (Khanlarian, 2011).

Since this study is using the Dynamic Geometry Software (DGS) tool GeoGebra for the delivery of WBH, it is essential to look at studies that have comparatively addressed the use of GeoGebra with that of traditional work given in class and at home. GeoGebra is described as a powerful discovery, teaching and learning tool (Preiner, 2008; Schumacher *et al.*, 2008; Reis and Gulsecen, 2010; Saha, Ayub and Tarmizi, 2010; Briscoe, 2012; Kul, 2012; Praveen and Leong, 2013; Gergelitsov´a, 2014; Mukiri, 2016). The use of GeoGebra is to find out if the selected tool can improve homework completion, performance and give good benefit to students' learning processes measured by their perceptions of the homework delivery methods.

In a study that examined the effects of using GeoGebra teaching strategies in a Malaysian Secondary school, a quasi-experiment of non-equivalent pre-and post-tests control group design study was conducted by Masri et al. (2016). There were one control group ($n = 17$) and one experimental group ($n = 29$) that were randomly selected from four classes. The experimental group used GeoGebra and the control group learnt via traditional teaching strategies. An achievement test and attitudinal survey were used as instruments in this study. The data were analysed using a one-way ANCOVA and one-sample t-test. The analysis showed that there was no significant difference between mean performance scores of students in the experimental and control groups. However, the experimental students showed positive attitudes towards using the GeoGebra software while learning mathematics topics. The results suggested that using GeoGebra could help Malaysian students' to enhance their mathematics understanding and performance (Schumacher *et al.*, 2008).

Saha et al. (2010) also used a quasi-experimental study with a non-equivalent control group, post-test only design that used GeoGebra in the mathematics classroom. The study examined the effects of using the free-software tool in the learning of Coordinate Geometry among students who had spatial ability issues. Students were put into categorise of having high-spatial ability (HV) and low-spatial ability (LV). A total of 53 secondary school students in Kuala Lumpur participated in the study. Students were assigned to two different groups. One group was taught Coordinate Geometry using GeoGebra while the other learnt the traditional way. Students' mathematics achievement was measured using the post-test score at the end of the intervention. Independent samples t-test results showed that there was a significant difference in mean mathematical achievement between the GeoGebra group ($M = 65.23, SD = 19.202$) and the traditional teaching strategy group ($M = 54.7, SD = 15.660$); $[t\ (51)\ =\ 2.259, p\ =.028\ <.05]$. The study also found that the HV students performed better than the LV students in both groups. In addition, the study found that there were no significant differences between HV students assigned to the GeoGebra group and HV students assigned to the traditional group. Meanwhile, the LV students in the GeoGebra group ($M = 64.07, SD = 21.569$) significantly outperformed the LV students in the traditional group ($M = 48.79, SD = 15.106$); $[t\ (51)\ =\ 2.222, p\ =.036\ <.05]$. The results of the study suggest that the use of GeoGebra improved the students' performance in learning Coordinate Geometry (Saha, Ayub and Tarmizi, 2010). However, students were allowed to interact with the GeoGebra tool at will and resubmit their assigned task multiple times and improve their score and that this behaviour was not the same with the PBH group. It was perceived by the researchers in this study that this behaviour contributed towards the students' performance goals and mastery motives, which facilitated the pursuit of higher homework scores (Saha, Ayub and Tarmizi, 2010).

Using an automatic evaluation system for construction geometry with GeoGebra called Geo Test, Gergelitsova and Holan (2014) evaluated construction assignments assigned by 100 teachers on 4000 students in 100 classes in the Czech Republic. All students were assigned the same task. The answers that were submitted were checked for the correctness of instruction and additional marking criteria such as the amount of support or help the student received from internet sources and their class teacher. The student was able to use the teacher feedback and the support features to resubmit their work multiple times to get an improved score. More than 90% of the homework tasks that students attempted to solve were completed with the correct answer (Gergelitsová and Holan, 2016). The study concluded that by using Geo Test to support and evaluate the students' homework construction using the GeoGebra tool increased independent work, interaction, cooperative engagement with their peers and class teacher, improved levels of self-efficacy and initiated faster feedback. Furthermore, the study also concluded that the use of GeoGebra with Geo Test had a positive impact on students completing the assigned task successfully.

Student frustration that was experienced when completing WBH or PBH tasks in some studies has been associated with anxiety and technical issues, especially when syntactical errors have been made (Ceaparu *et al.*, 2004; Bessière *et al.*, 2006). Bessiere et al. (2002) and Ceaparu et al. (2004) defined user frustration as being stopped in a process by a technical challenge or issue. Adaptations of their survey item questions were found in previous studies to try to capture student perceptions about homework completion and technology usage. The survey items included statements such as: I feel anxious when I run into a problem on the computer or have a problem with the WBH software; I feel helpless when I encounter a problem on the computer or have a problem with the WBH software; when there is a problem with a computer that I can't immediately solve, I keep trying until I have the answer and finally, frustrating experiences with the WBH software severely impacted my ability to get the assignment completed (Demirci, 2007; Khanlarian, 2011; Nguyen, Hsieh, & Allen, 2006).

Student cooperation as a construct involves students that work together through whatever means to solve problems. This is achieved in the homework setting by communication techniques used both in and out of school, and WBH completion through collaboration has been positively associated as part of this learning experience (Nelson Laird and Kuh, 2005). Laird and Kuh (2005) researched technology usage in a university setting in the United States and found that students increased their interaction time with their task and collaborated far more with their peers in and out of the university setting. The cooperative learning experience was associated with greater engagement and as a result, group learning activities were organised for the classes that participated in the remainder of the study. It was expected or hypothesised that as students experienced more problem-solving activities, their appreciation for collaborative learning would increase (Nelson Laird and Kuh, 2005). This was a similar finding in Dermici's (2007) study of physics students who used WBH. Students genuinely perceived that they interacted in more positive ways with their class peers, family members and their teacher when trying to complete WBH tasks.

In summary, there seems to be some agreement amongst researchers in the field of WBH versus PBH studies that WBH is at least as effective as PBH and this is supported by the studies that attained the results of "at least equivalence" when comparing distributive homework methods (Bonham et al., 2003; Dufresne et al., 2002; Hauk et al., 2015; Hodge et al., 2009; Nguyen & Kulm, 2005). There is also consistency in these studies with student perceptions as to the benefits derived from using WBH tools. These benefits are the provision of instant feedback, help and support facilities, the availability of multiple homework submissions and technological facilities or equipment that facilitates the communication amongst peers and class teachers. The mathematics WBH studies mentioned draw on the students' perceptions that the immediacy of feedback and the availability of multiple homework submissions is an important and integral part to the students attaining an improved homework score.

2.3 Constructs that could affect Mathematics Homework Completion and Performance

Several factors could affect the completion of mathematics homework and performance, and this study is by no way exhaustive in its pursuit of these factors. In the literature review on homework completion, the following constructs below came to the forefront and are discussed.

2.3.1 Homework

Mathematics homework completion in UAE secondary schools has been identified as a problem as students rarely engage consistently in the process (Clarke, 2016; Sartawi et al., 2012). Homework is defined as "tasks assigned to students by school teachers that are meant to be carried out during non-school hours" (Cooper, 1989, p. 7). However, formal definitions of homework must be flexible given the different types of homework, the length and quantity of homework, the time frame for completion, whether it is to be completed independently or with peers, the level of parental involvement, whether it is part of the school ethos, whether it will be marked and recorded, and finally, whether it is compulsory (Cooper, Robinson, & Patall, 2006; Coutts, 2004; Libbey, 2004). Up until the 20th century, homework was not viewed as a possible social problem (Gill, 2004). Students fortunate enough to attend school suffered the burden of hours of homework each evening, including weekends (Reese, 1995). Students during the 19th century faced compulsory school attendance in the United States, and to some extent in the United Kingdom, up until age 14. This requirement was mostly dependent on the family income at the time, as labour was a crucial issue concerning the family's ability to survive. With this in mind, education was considered a luxury item, and only a tiny portion of the population would actually attend school in these emerging industrial economies (Gill, 2004). The method of teaching subject matter at this time was often through drill and practice, memorisation and recitation (Gill, 1996). This rigorous approach to learning often required students to prepare extensively at home in order to be successful in the classroom (Gill, 2004).

Towards the end of the 19th century, a progressive educational movement arose that introduced a scientific method of evaluating education. With this movement came the first critique of homework because of a study on children's health and learning by Dr Joseph Mayer Rice (Rice, 1897). Dr Rice focussed on children's spelling, school drills, memorisation and recitation pedagogy. The conclusion of the study was that spelling learnt at home was not related to children's ability to spell (Gill, 1996). In short, it suggested at the time that spelling given for homework was meaningless, as it did not raise academic achievement. Dr Rice's conclusion gave rise to educational discourse and further research into homework.

During the early part of the 20th century, arguments over homework became more intense and often heated amongst educators, researchers, parents and policymakers (Omlin-Ruback, 2009). Those in favour of homework at the time argued that homework encouraged a culture of "self-discipline and good study habits" (Omlin-Ruback, 2009, p. 7). It was also viewed as an integral part of the disciplining of young and adolescent children. Conversely, those who argued against homework suggested that it overly exposed academics, frustrated social interactivity and limited leisure pursuits (Gill,1996). The idea that memorising literary material and scholarly practices led to the acquisition of knowledge was widely accepted at the time, and schools encouraged this practice as a homework strategy (Cooper et al., 2006). However, by the mid-20th century, educationalists were arguing for more emphasis to be placed on problem-solving strategies as opposed to mere drill and practice or rote learning techniques (Gill, 2004).

Historically, extreme cases of campaigns to abolish homework altogether have appeared, whilst other educators have been prepared to take a more progressive attitude and sought ways in which to reform homework (Gill, 1996). Subsequently, two schools of thought emerged, the homework abolitionists and the homework reformers. The homework reformers were a tiny and helpless minority during the late 1920s and the abolitionists at the time were very strong, adamant and extremely vociferous about the ills of homework (Omlin-Ruback, 2009).

Homework, therefore, has been a subject of debate in education since the industrial revolution, and attitudes towards homework have changed according to economic and social circumstances at a given time (Gill & Schlossman, 2000). Gill and Schlossman (2000) write that educators in the early part of the 20th century believed homework helped students to discipline and train their minds. After 1940, people increasingly believed that homework interfered with other home activities. Consequently, this triggered a strong verbal reaction against it. In the late 1950s, when the Soviets launched *Sputnik*, educators believed that the United States system of education lacked proper rigour as they feared the United States falling behind the Soviet Union in the quest for technological supremacy and space exploration. As a result, schools viewed ample homework as a solution to the problem. By the 1980s, it was reported that the view about homework had changed again: homework could be harmful to the mental wellbeing of students and could subsequently affect their mental health (Albright et al., 2007; Kralovec & Buell, 2000; Corno,1996). Since then, several studies have sought to determine the effectiveness of homework on student achievement; however, the studies are inconclusive about the benefits of homework (Marzano & Pickering 2007; Albright et al., 2007; Cooper, 2007). The ideological changes over time have been periodic and seemed to have met Western emerging economic needs and values at associated times. The lack of consistency between homework and ideology, combined with the lack of conclusive results to determine homework's value, does not lend credibility to the model of schooling with homework. With this thought in mind, it is then hard to impose such a model on a people whose identity involves established religious practice such as the memorisation and rote learning of the Holy Qur'an.

During the 1930s to 1940s homework was abolished in many schools, districts and councils from one side of the Atlantic to the other at the primary and early secondary school level (Cooper et al., 2006). Post-Second World War, the issues raised by the homework reformers started to gain momentum and popularity in trying to reshape students' minds and skills for a developing post-war order. The reformers were working to try to find a new pedagogical approach to teaching and learning where homework would be an integral part of it (Gill & Schlossman, 2000). They wanted to take learning away from textbooks and get students to be involved in more activity-based learning associated with the philosophy of constructivist learning principles (Gill & Schlossman, 2000). The reformers were concerned about the amount of time associated with homework tasks and they worked to devise policies that could address these issues (Omlin-Ruback, 2009). The reformist formulated ideas that were a direct result of progressive educators at that time. The notion of "learning by doing," "student-centred learning," and "educating the whole child" were phrases indicative of the change in educational philosophy at that time (Gill, 2004).

The Russian launch of the Sputnik satellite in 1957 changed the homework debate for the United States and its allies. The Cold War brought about competition for technological advancement and the need for greater rigour in educational systems that enabled citizens and countries to compete for future prosperity and superiority (Omlin-Ruback, 2009). As a result of proposals made by post-war reformists, homework was increased. This trend continued up until the Vietnam War when culture wars over social inequality, civil rights and gender inequality were also fought throughout the developing world (Gardner, 1983). Homework was again viewed as pressuring young people at the expense of social, recreational and creative activities (Cooper, 1989). This attitude from the abolitionists continued until the 1980s when the cycle changed again in favour of the reformists. The reformists were concerned that not giving enough homework was creating educational problems and contributing to a lack of social discipline and order (Gardner, 1983). The new attitude towards achievement led to strict standards being imposed throughout the United States, Europe, Africa and Asia with many schools or policymakers demanding that homework be given at earlier grade or year levels (Omlin-Ruback, 2009).

With the introduction of the oil economy in the UAE in the late 1960s, and its further development in the 1980s, the rush to modernisation included vast expenditure on education. The automatic increase in the expatriate population that followed brought about the emerging school of thought on homework at the given time. It would flow periodically with worldwide events from then on. However, since contracts for education-system development was given primarily to Western companies, it was unlikely that the developers would have had a thorough understanding of how homework would impact Islamic and cultural values over time.

The most comprehensive study on homework has been by Cooper (1989). Cooper synthesised almost 120 studies on the effectiveness of homework and found that there was a positive correlation between homework and student achievement (Cooper, 1989). However, his findings did vary significantly with the age of the student. Elementary-aged children seemed only to have a small effect size ratio, whereas junior high school students had a moderate effect size ratio. For high school students, the effect size ratio was almost double that of junior high school students. The study indicated that the more homework high school students completed, the better their chances of achieving higher marks in their final examination (Cooper, 1989). In 2006, Cooper et al., investigated and synthesised research on the effectiveness of homework from 1987–2003. The 2006 study examined any causal relationship between homework and student achievement. Part of this process was achieved by comparing 20 experimental design procedures that involved experimental groups (i.e., with homework) and control groups (i.e., with no homework). The study found that 14 out of the 20 groups were pro-homework, indicating that there were positive effects. In addition, 50 studies were examined to determine whether any relationship held between the amount of time spent on homework and achievement. Cooper's studies found that with limited exception cases, a causal effect held between the amount of homework and student achievement. This relationship was found to be positive and statistically significant (Cooper et al., 2006). Therefore, Cooper et al. (2006) postulated a link between homework and academic performance.

The outcome of the research reinforced Cooper's earlier findings that there was a statistically significant difference between the amount of homework students do and their achievement. Their conclusion highlighted particular points of relevance, which included that homework and achievement varied from student to student and that the amount of homework assigned and completed was a factor in determining its effectiveness (Cooper et al., 2006).

Cooper's (2006) studies followed three experimental designs. The first compared the overall achievement levels of randomly assigned students to groups who were given homework, and students who were not given homework. These experiments compared homework and no-homework groups, finding a positive relationship between homework groups and achievement scoring, with effect sizes varying between $d = .39$ and $d = .97$ and a weighted mean d-index of .63. The experimental design of the synthesised studies showed a positive effect on the mathematics and language arts unit tests taken by the homework groups (Cooper et al., 2006). Notably, four of the five synthesised studies were conducted at the elementary grade level, going from second to fifth grade. The results of the study were not at all surprising since the homework given was to help prepare students for their upcoming unit tests. The students who completed the homework tasks were better prepared for the tests than those who were not given the homework, so the homeworkers achieved higher scores in those units. The problem with this experimental design was that when students were measured on standardised assessments over the long term (exams), the positive effect of homework was not evident. As a result, the synthesised research was labelled as flawed, since there was no way of knowing or concluding a causal relationship existed between students who completed homework tasks and exam performance (Cooper et al., 2006).

The second approach used by Cooper et al. (2006) in his analysis of homework was to use data from the National Education Longitudinal Study (NELS) in 1988, 1990, 1994 and 2000. The data tried to measure time spent on homework and its effect on achievement scores (Cooper et al., 2006). The tests were conducted on secondary students (middle and high school). They gave positive results suggesting again, evidence of a causal relationship between the amount of time spent on homework and higher exam results. Thirty studies were completed, with the majority using multiple regression analysis or structural equation modelling to make predictions about variable factors. Most of these studies found a positive correlation between the amount of homework students did and achievement. These studies used controlled outside-factor influences, such as the amount of time students spent completing the task, who received help of any kind, distractions, and many other potentially confounding variables (Dettmers, 2010).

Cooper et al.'s (2006) third approach used a bivariate correlation between the amount of time spent on homework and the mark given or awarded on an assessment. The difference between this approach and the others was that no other variable was taken into consideration that could confound the results. The absence of variables that could have had an overall impact on the amount of time spent on homework was seen as a possible limitation by the researchers (Cooper et al., 2006; Kohn, 2006). However, they found in 32 of their studies with 35 samples, 50 of the 69 correlations reported were positive, 19 were negative, and there was a causal relationship between time spent on homework and the grade awarded, as well as the standardised test score (Cooper et al., 2006). Homework had a stronger achievement correlation value than the standardised score (r = .25) and (r = .4), respectively. The researchers themselves, along with fierce critics such as Kohn (2006), noted problems with their methodological approaches in most of the studies that they considered. However, the researchers still conclude that, in general, the findings across subject areas, including mathematics, confirmed a positive association between achievement and time spent on homework (Cooper et al., 2006).

In 1985 Walberg, Paschal, and Weinstein compiled 15 homework studies and drew similar conclusions as to the effectiveness of homework. According to Walberg et al. (1985), graded homework within a specified period had a significantly positive effect on student achievement and subsequently on their learning. Their studies also concluded that student homework that was not graded or had no feedback had no effect on student achievement (Walberg, Paschal and Weinstein, 1985). Walberg et al. (1985) compiled non-subject-specific studies from elementary and secondary schools.

In 1999, Rayburn and Rayburn conducted experiments using managerial accounting students at college and found that students who regularly completed homework problems attained on average, significantly higher grades in their exams (Rayburn and Rayburn, 1999). However, the method of exam assessment included multiple-choice questions, and this was considered a severe limitation in the study, as it encouraged a trial-and-error type approach that would be difficult to account for. Another potential problem with this study could be that the students who performed better would be able to complete more homework and get better results. So, the homework and attainment might not be causally related but could depend on some third variable (e.g., the general level of performance).

Doorn, Janssen, and O'Brien (2010) surveyed several students across a range of disciplines and found that the majority of the students interviewed said that homework that was marked and graded promptly was extremely helpful in learning material content that was delivered via a WBH tool (Doorn, Janssen and O’Brien, 2010). The students surveyed in this study "overwhelmingly reported that Online homework was beneficial in understanding the material and preparing for exams" (Doorn, Janssen and O’Brien, 2010, p. 16). These statement items came up as being statistically significant. The students said that they liked the tool's flexibility and its provision of immediate feedback. However, the study investigated only student perceptions, and it did not compare traditional homework with WBH. Therefore, the study would not be able to conclude whether WBH was more suitable or worse than paper-based homework (PBH). It could provide useful information only in relation to the possible behavioural attitudes of students about WBH.

In relation to mathematics homework, standardised mathematics scores were compared across multiple countries, and no link was found between mathematics achievement and the amount of homework completed (Boli, 2006). The study's findings were similar to that of Mikk (2006), where it was found that countries that gave students many mathematics tasks in different forms for homework performed worse than students who were given only a small amount of mathematics tasks in different forms for homework (Mallick *et al.*, 2011). The studies concluded that a distinction should be drawn between the number of homework assignments given by the teacher and the amount of time students spend on the homework activity (Boli, 2006; Mikk, 2006; Trautwein & Köller, 2003). Ironically, in a later study by Trautwein (2007), using data from Germany, it was reported that the frequency of the homework was more important than the amount of time students spent on it (Trautwein, Lüdtke, & Pieper, 2007).

Using data from TIMSS in 2003, Baker et al. (2005) found that teachers in countries who had students with lower-than-average achievement scores gave more homework than teachers in countries with higher achievement scores (Falch, 2011). Dettmers et al. (2009) used other internationally comparable achievement test results and found that for mathematics, there was a positive correlation between achievement and time spent on homework (Falch, 2011). The mixed results are suggestive of confounding variables such as more homework maybe set in schools with children from privileged backgrounds; there are also gender differentials to consider in addition to social demographics. The claim that time spent on homework is positively related to achievement was tested in three studies. The first study was prompted by the PISA 2000 findings that suggested longer homework time is associated with higher achievement (OECD, 2001). The second study was designed to address the limitations that were highlighted in the first, and it used a sample of Germany secondary school participants involved in the Trends in International Mathematics and Science Study (TIMSS). The third study examined the effects of homework behaviour on achievement. Behaviour was split into two categories of "homework effort (i.e., conscientious execution of homework assignments) and homework time" (Trautwein, 2007, p. 383). Comparison of homework time was contrasted with other variable indicators of homework frequency and the students' homework behaviour. The results of the three studies suggested that completing homework tasks is positively associated with achievement. However, the positive effects of assigning homework tasks and their completion are not captured by the "time on homework" measure (Trautwein, 2007).

Teachers who participated in the 2007 TIMSS suggested that some mathematics homework was given to students in all countries except Holland. The teacher and student data were merged, and 63.6 % of the surveyed students in Holland said that they are never assigned mathematics homework, and those who did were assigned it only sporadically (Falch, 2011). By contrast, in Germany and Hungary, 90% of students surveyed said that they got mathematics homework after nearly every lesson. The data seemed to suggest that in New Zealand, Sweden, England and Scotland, mathematics homework was given to students on occasion after lessons. Appendix 3 shows the percentage of homework given to students in TIMSS participating countries. Western countries are displayed because the model adopted in the UAE was initially of Australian origin. A possible dilemma arises when one considers the results from Asian countries where attitude, cultural discipline and belief structures are part of their identity and perhaps very different to results attained elsewhere (Greenhalgh, 2016a). Singapore, the Hong Kong Special Administrative Region (SAR), Korea, Chinese Taipei, and Japan continue to outperform all other TIMSS participating countries in mathematics at the fourth and eighth grades (Mallick *et al.*, 2011). These countries have a rigorous regimented structure of education that includes many studies outside of the classroom. So much so that their success in this area of educational attainment has been widely undercut by having the highest student suicide population rates amongst all Organisation for Economic Cooperation and Development (OECD) countries, despite outperforming Western countries for the past 20 years (OECD, 2016). The 2016 PISA test scores—another external measure to assess student performance internationally—indicated that eight of the top 11 countries were the Asia-Pacific countries. They are reported to emphasise "competition, endurance, and pressure and [their] students spend almost twice as much time studying as children in other countries" (Greenhalgh, 2016b, p. 4).

Aside from the early abolitionists, criticism of homework has continued since synthesised studies such as Cooper's and others appeared (Kralovec & Buell, 2000).

Homework was heavily criticised for disrupting family life, overburdening children and limiting learning to only what the curriculum content thought was relevant. *The End of Homework,* by Kralovec and Buell (2000), attacked the United States competitive culture that stemmed from the Cold War period as being detrimental to family values and social wellbeing. In addition, students who were of different cultural and ethnic backgrounds and those who were economically disadvantaged or disenfranchised were unwittingly penalised because of their inadequate social environments, which made doing homework practically impossible for them (Buell, 2000). This type of inequality would make it extremely hard for many students to complete homework tasks with any degree of success at home. One suggested alternative to combat this inequality was to try to extend the school day instead (Crain, 2005). However, Bennett and Kalish (2006) argued that homework was harmful to children's health and social wellbeing and that extending the school day would only infringe upon time spent on other worthwhile social practices, such as sports (Bennett and Kalish, 2006). Also, the amount and quality of homework was severely criticised, as well as some teachers' professional inability to assign appropriate levels, types and quantities of homework. Bennett and Kalish (2006) provided empirical evidence that too much homework had a negative effect on student health, family life and time spent socially interacting with family members, colleagues and their peers.

In the book *The Homework Myth: Why Our Kids Get Too Much of a Bad Thing*, Kohn (2006) directly attacks research on homework and personally condemns the authors. Kohn writes that the lead researcher on two meta-analysis studies, Harris Cooper, massaged the numbers in his research until he was quoted as saying that he had to get "something—anything—on which to construct a defence of homework for younger children" (Kohn, 2006, p. 84). Kohn (2006) concludes that the research failed to demonstrate the effectiveness of homework as an instructional tool because results for homework scores were often included in the overall assessment of the student's performance. As a result, any correlation found between homework scores and a student's overall grade could be misleading (ChallengeSuccess, 2012). He recommends that changing the state of mind that homework is mandatory was paramount in the students' beliefs about whether homework would be assigned, referring to the expectation of homework as the "default state" (Kohn, 2006, p. 166). Kohn felt that teachers should only assign homework if they can justify it as "beneficial" to the student (Kohn, 2006). This meant that the students were actively engaged in an assigned task that would encourage the learning for real-life situations. In short, this activity might entail experiments, cooking, doing puzzles with the family, watching a good TV show, or reading good books. The amount of homework and how much should be completed, it is argued, should be left up-to-the student to decide, as some studies have concluded that have also questioned the role of homework (Marzano & Pickering 2007). Kohn (2006) makes some valid points in his case against homework, such as assigning homework that has benefits to students as opposed to giving homework just for the sake of it. However, Kohn has been severely criticised by researchers for trying to misrepresent research studies and for sending an inappropriate and inaccurate message that research into homework is flawed and inaccurate (Marzano & Pickering 2007).

2.3.2 Self-Efficacy

Levels of self-efficacy have been questioned in the UAE at both the teacher and student level when using technology to support teaching and learning (Almekhlafi and Almeqdadi, 2010). There is also the concern that due to cultural differences and the family support structure in the UAE, students lack the skills required to complete set and follow-up tasks independently without the support of additional parties. Self-efficacy is defined as a person's ability and level of confidence in performing, participating or completing a specific set of academic tasks (Song and Thompson, 2011). Teachers' self-efficacy beliefs towards the use of technology integration in the UAE have been considered a crucial factor that affects teachers' integration of technology (Al-Awidi and Alghazo, 2012). Mathematics self-efficacy is a maths-specific personal assessment of the students' competence to perform particular mathematical skills or tasks (Bandura, 1978; Bembenutty, 2011; Pajares & Miller, 1994). Self-efficacy is noted as having four main factors that can affect it: experience, modelling, social persuasion and physiological factors (Bandura, 1978).

The first factor listed, experience, was linked with performance accomplishment and mastery of an event or topic that gives the feeling of success. Hodges (2008) has argued that if a student feels confident about performing set tasks in school, he or she is likely to be able to go home and complete a similar task with additional extended material. Similarly, if students are struggling to master a topic and are uncertain about their skill level, they may develop a sense or feeling of failure. This feeling could lower self-efficacy (Murray *et al.*, 2006; Kats-Gold and Priel, 2009).

The second factor, modelling, is based on the belief that if one sees it being done, one can do it as well. Students benefit from interacting with their peers, friends, parents or others, and as a result, they feel able to reproduce what they see. However, if students are not exposed to this mode of social interaction, they may lack the confidence needed to complete a task.

The third factor, social persuasion, concerns persuading students that they can participate in a set task and that participation is itself a measure of success (Song and Thompson, 2011). Social inclusion is important for this theory to work. If a student feels disenfranchised from others and feels he has difficulty in understanding processes and concepts being taught, this feeling may lower self-efficacy (Locklear, 2012; Felix, 2008).

Finally, physiological factors can have a drastic effect on a person's self-efficacy. Symptoms of stress and anxiety can inhibit performance and alter attitudes that will prevent the satisfactory involvement and completion of set tasks. According to Bandura (1978), "Individuals are more likely to expect success when they are not beset by aversive arousal than if they are tense and viscerally agitated" (Bandura, 1978, p. 8). In mathematics, self-efficacy is related to the feeling of mathematics anxiety (Ashcraft, 2002).

2.3.3 Mathematical Anxiety

Mathematics anxiety can be described as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Menges *et al.*, 2007, p. 551). Feelings of incompetence associated with the fear of failure are foremost in students' minds (Perry, 2004). It is not uncommon for some students to feel physically sick at the thought of having to do their mathematics homework or mathematics test. Researchers have identified mathematics anxiety in two categories of coursework: homework and tests; since students most commonly cited these two tasks as the leading causes of stress and unsettling behaviour, even though mathematics anxiety is not limited to these areas (Ashcraft, 2002; Perry, 2004; Menges *et al.*, 2007).

Richardson and Suinn (1972) devised a mathematics anxiety rating scale (MARS) that tried to determine a student's level of anxiety. They created an exam consisting of 98 questions and tried to measure the reactions of students using mathematics in various situations (rated on a 5-point Likert scale). After that, mathematics anxiety scores were considered by some researchers as the "gold standard" (Ashcraft and Kirk, 2001, p. 22). However, due to the extensive nature of the exam, researchers have created shorter versions called sMARS, the scoring of which continued to be highly correlated with the original MARS scores (Ashcraft and Kirk, 2001). The experimental conditions included standardised tests and homework, and sMARS was considered by the research community for many years to be an acceptable measure of mathematics anxiety in students of particular ages (Wigfield and Meece, 1988; Bull, 2009). Fennema and Sherman (1976), using a self-developed mathematics attitudinal scale, found that mathematics anxiety was highly correlated with mathematics ability ($r = -.89$) in a sample of secondary school students. However, they concluded that more research was needed to find out whether these constructs could be distinguished more clearly. Most of the studies in the area of mathematics anxiety have been conducted with high school (secondary) and college-age students, and therefore little is known about younger populations. The research studies that have taken place with younger populations show that mathematics anxiety scores are similar to that of test and homework anxiety scores in the sense that they increase as the pupil gets older (Wigfield and Meece, 1988). The research suggests the possibility that with age, students develop and attach importance or relevance to their studies, and that this could be a contributory factor to increased levels of anxiety that could potentially affect levels of mathematics performance.

Hembree (1990) conducted a meta-analysis to determine the effect size or commonalities between previous research studies. His research brought together the results of over 150 studies on mathematics anxiety. He concluded that anxiety in mathematics was related to underperforming in formal mathematics assessment tasks such as tests and homework. This had a subsequent effect on those students who achieved low scores to avoid mathematics or at least take a disliking to it (Hembree, 2006). Several years later, Ashcraft and Kirk (2001) looked at the causal relationship between anxiety in mathematics and the students working memory capacity. The study confirmed Hembree's findings that students with a high level of anxiety in mathematics enrol in fewer mathematics-related courses and score lower in the courses they do enrol in (Ashcraft and Kirk, 2001). They also found that anxiety with mathematics is a result of the mental processes involved in calculations (Ashcraft and Kirk, 2001). These findings led Ashcroft and Kirk to split mathematics-related anxiety into two categories: test anxiety and numeric anxiety. In general, students who suffered from anxiety related to mathematics had very little confidence in their ability to go through mathematical processes. As a result, they found it very difficult to solve problems and therefore tended to avoid mathematics (Hembree, 1990). This avoidance led to a lack of mathematical exposure or practice that perpetuated a somewhat vicious spiral (Ashcraft and Kirk, 2001).

Mathematics anxiety stems from a variety of factors. It can arise as a result of the nature of mathematics as a study itself (Ashcraft and Kirk, 2001). The practice of processes involving information recall or memorisation, the use of formulae, the concepts that you are required to link together to solve problems can be a daunting affair (Wright & Miller, 1981). If a student misses a part of the linking process stage or fails to grasp the understanding of it, they may well find themselves left behind or out of reach. The mathematics then becomes overwhelming, and the student feels that they cannot keep up (Perry, 2004). The student's apprehension or fear of learning mathematics is often as a result of poor situational experiences that tend to exacerbate feelings of failure (Ibid).

Poor mathematical performance by students is often a result of high mathematical anxiety and low self-efficacy (Smith, 2009). According to Smith (2009), the use of WBH tools to improve the teaching and learning of mathematics should be monitored over time, but certain constructs must be considered when evaluating their impact on student learning. In addition, Smith (2009) believes that mathematical anxiety is already conditioned in students when first they enter school. Discoveries have been made that some 85% of students in mathematics classes have mathematics anxiety (Smith, 2009; Perry, 2004). Mathematics anxiety and self-efficacy in the class are essential topics in the discussion of students working at home, where it is highly likely that the problem could be further exacerbated (Smith, 2009). Certain studies into WBH have indicated that WBH tools can provide students with a degree of flexibility in the way in which they go about solving problems (Brewer, 2009; Locklear, 2013; Nguyen & Kulm, 2005). The authors of these studies have argued that due to the flexibility of WBH, regarding how students can learn and solve problems, their engagement with mathematics increases; they experienced lower levels of anxiety and had a more positive attitude towards learning.

Ashcraft (2002) has determined that mathematics anxiety in students is as a result of negative attitudes about mathematics and a negative self-image when it comes to their competency in mathematics. Mackenzie (2002) supported this idea and said: "Intrusive thoughts such as worrying about performance and fear of failure can negatively affect an individual's ability to perform mathematically" (Mackenzie, 2002, p. 167). This observation is even more pertinent when students are required to solve problems and perform mathematical tasks away from their peers and their class teacher. Hembree (1990) found that positive attitudes towards mathematics and mathematics homework led to lowered mathematics anxiety and heightened self-efficacy. This higher level of self-efficacy led students to be able to work on mathematical problems and tasks outside of the classroom environment, and it enabled them to complete homework tasks with some degree of success (Hembree, 1990).

The most common reaction of a person with mathematics anxiety is avoidance (Ashcraft, 2002). Both Ashcraft (2002) and Hembree (1990) have argued that students who regularly did not attempt mathematics homework tasks were likely to be suffering from anxiety. MacKenzie (2002) looked at undergraduate mathematics attitudes in entry-level mathematics courses in universities in the United States. She found that most students surveyed enjoyed mathematics at the elementary school level, and less than half of the surveyed population enjoyed mathematics at the secondary school level. Mackenzie found that mathematics avoidance levels were extremely high for students taking humanities and attributed this to high anxiety about mathematics scores. A strong indicative factor, according to Mackenzie, was the students' poor experiences in mathematics at the secondary school level. Mackenzie felt that students who had perceived themselves as not being very good at mathematics and had high levels of anxiety would choose other areas to study (Mackenzie, 2002). Mackenzie (2002) concluded that avoiding mathematics would eliminate many career paths for prospective employees such as science, engineering, nursing and business. Educational institutions would not be helping students if they continued to ignore low self-efficacy levels of students and low confidence levels. Educators would just be continuing the spiral of students avoiding number work, increasing gaps in their mathematical skill-building and closing the door on specific career opportunities (MacKenzie, 2002). This effect of mathematics anxiety on employment streams has raised serious concern for policymakers in the UAE, as it marginalises the career paths the country wants to promote as part of its 2030 vision (ADEC, 2012).

Unlike Mackenzie (2002), who focussed on student attitudes and perceptions, Goulding et al. (2002) attribute much of the blame for mathematics anxiety on elementary and secondary school teaching. The researchers focussed on primary and early-years teaching in the United Kingdom, finding that a teacher's knowledge of the subject and pedagogy was insufficient to reduce levels of anxiety in young children (Goulding, 2003). Goulding et al. (2002) felt that if learners at the undergraduate level suffered from mathematics anxiety or had experiences associated with low levels of it, then this anxiety would be passed on to younger students, perpetuating a generational cycle of mathematics-anxious pupils (Goulding, 2003).

According to Ashcraft (2002), one way to alleviate mathematics anxiety is to improve teaching strategies in early education and then build on students' attitudes towards mathematics (Ashcraft, 2002). The performance levels of pupils will improve if anxiety is alleviated, and confidence in learning is instilled. How a teacher approaches mathematics, and mathematical problem solving can drastically affect the students' ability to feel confident in performing the operations they are shown or in using similar techniques (Hodge, 2002).

Hembree's (1990) study compared four teaching strategies to alleviate mathematics anxiety: classroom intervention, which attempted to reduce the levels of mathematics anxiety experienced by all children in the classroom; behavioural treatments, which attempted to reduce feelings of nervousness and tension; cognitive treatments, which attempted to diminish concerns about mathematics as a subject; and cognitive behavioural treatment, which attempted to remove both the intellectual concerns and the negative feelings associated with studying mathematics (Hembree, 1990). It was found that the cognitive behavioural strategy was the most effective of these treatments, as it helped reduce pre-conceived notions about mathematics being difficult as a subject (Hembree, 2006). By presenting mathematics and mathematical tasks in a variety of ways in the classroom, instructors could make the lessons, perhaps more stimulating and engaging, so students could more easily continue their work at home. This helped to partially overcome initial fears and anxieties associated with studying and learning mathematics (Hembree, 1990).

In contrast to Hembree's (1990) and Ashcroft's (2002) methods to diminish mathematics anxiety, Perry (2004) has argued that students must be proactive in their approach to learning by acknowledging their strengths and weaknesses with the support of their teacher. Any plan that teachers and students devise must include seeking the appropriate help on-time so that the student does not fall behind and then develop a feeling of being left behind. Also, Perry argues that classwork and homework receive appropriate feedback promptly so that students can understand the key processes of the concepts (Perry, 2004; Farrell, 2006). Once this is achieved, students can repeat particular processes in different contexts, be extended or moved on (Farrell, 2006). In addition to Perry (2004), Farrell (2006) suggests that students need to keep up to date with their homework and resist a culture of yielding easily to difficulty. He recommends that teachers should tell students that mathematics is a skill that needs constant development and that this development happens over time. If a positive attitude is kept, self-efficacy in mathematics will increase, and the knock-on effect will be to help reduce levels of mathematics anxiety (Farrell, 2006).

2.3.4 Parental Involvement

A key construct that seems to have been left out from the surveyed literature on mathematics anxiety is the involvement or lack of it from parents. Often the help and support given or not given can increase levels of mathematics anxiety (Murray *et al.*, 2006). According to Murray et al. (2006), parent and child interactions over mathematics homework are crucial to the mathematical development of the child. After observing mother and father interactions with eight-year-old children doing mathematics homework, it was noticed that depression was evident in both parents and children in some volunteer samples (Murray *et al.*, 2006). The research showed that differing encounters with children produced different outcomes. It was noticed that school attainment and IQ were related to the parental strategies used to encourage "representational thinking and mastery motivation" (Murray *et al.*, 2006). However, the research studies seem to emphasise that the child can adjust their behaviour, have a certain amount of self-efficacy, and complete their mathematics homework with low levels of parental involvement and low levels of coercion. Moreover, mothers and fathers produced differing outcomes: "Notably, the influence of maternal homework support was more strongly related to child outcome than was paternal support. This pattern was reflected in mothers' greater involvement in children's schools and school-related activities" (Murray *et al.*, 2006, p. 125). However, it was also noted that a depressed maternal mood might drastically affect and interfere with all dimensions of mathematics homework (Murray *et al.*, 2006).

2.3.5 Motivation

The statistically significant findings within the Hodge et al.'s (2009) model told us that student perceptions about their increased mathematical understanding were due to them being more motivated to do WBH than PBH. They found that the WBH tool helped them to understand specific processes involved in answering questions by its "help" and multiple question facility. Students also found it easy to navigate around the WBH tool. The researchers found that the use of the WBH tool played "an important role in students' motivation to complete more homework, possibly because of the immediate feedback (simple as that feedback may be) as a means to increase their mathematical understanding" (Hodge et al., 2009, p. 622). In determining whether the WBH tool contributed to students' study habits or learning strategies, the correlation results of the study indicated that there was a statistically significant difference between the Peer Learning Scale and the Help-Seeking Scale, $r(1283) = 0.534$, $p < .01$. Even though the scales measured different types of student learning strategies that could be considered similar in construction, a positive and significant correlation between them was found. Students were also asked to respond to whether they were more motivated to complete WBH than PBH, and a statistically significant correlation was found between the "motivated" item and those who interacted with their peers (i.e., with "peer learning"), $r(1300) = .126$, $p < .01$. In addition, statistically significant correlations were shown between, on the one hand, the "motivated" item and those students who used the "help-seeking" tool, $r(1297) = .094$, $p < .01$, and on the other, the "motivated" item and those students who had a very good idea about their grade outcome and the actions required of the desired grade (i.e., "control of learning beliefs"), $r(1309) = .232$, $p < .01$ (Hodge et al., 2009, p. 622). In short, the results suggest that students considered to be motivated to complete their assigned homework using the WBH tool were very likely to seek out help and the assistance of their peers in order to complete the task. Moreover, students who aimed to attain a B grade or higher had high levels of self-efficacy, which accounted for 5% of the total variance (Hodge et al., 2009). This meant that those students were far more likely to indicate that they preferred to use the WBH tool rather than be given PBH. The results showed that individual intrinsic motivation and computer efficacy are important factors in determining the level of effort used and whether students perceive the tools to be useful. These findings are also consistent with the findings of Peng (2009), who used an Online homework system to submit accounting homework. Peng (2009) advised that educators and tool system designers should consider implementing Online homework systems and "determine which types of students benefit most from the use of these systems in classrooms and beyond" (Peng, 2009, p. 263).

2.3.6 Effectiveness of the Technology

A construct that could affect the performance of students' in both positive and negative ways is the technology tool or tools that are used. How useful technology tools are, in getting students to first, complete the assigned task and second, to improve on their mathematical performance, as measured by their homework score in this study is crucial in determining whether to use the tool to support the teaching and learning process (Affouf and Walsh, 2006).

According to Affouf & Walsh (2006), a better measure of a WBH technology tool's effectiveness is to see how students perform in their final exams.

In a study on the effectiveness of WBH assignments in a college algebra course, "effectiveness" was used as a measure of the homework score in comparison with exam performance (Potter & Johnston, 2006). Over three years, 1,653 students were monitored. Strong correlations were recorded between WBH and achievement in final examinations (Affouf and Walsh, 2006). The study concluded that WBH could be used as a good predictor of final exam scores. The study used a quasi-experimental design and was observational. It looked at the records of the students from 100 sections of them beginning college algebra classes between autumn 2002 and spring 2005. The curriculum was designed to include technology in assessing student achievement. Over the course's duration, students were required to complete between 40 and 50 WBH assignments. The assignments were exercises that the students had to complete in order to support their classroom learning (Affouf and Walsh, 2006). The completed WBH tasks contributed to 16% of their final mark. This weighting of the course material could account for why the WBL was a good predictor of the students' perception of their final exam mark. The WBH contained short-answer questions that received immediate feedback. None of the questions was multiple choice. The questions were algorithmically scrambled so that every time students revisited the task to try to improve their scores; they would encounter a similar problem with different numbers. The tasks set had due dates that were in line with the college teaching plan and a help feature to assist, guide and support students. In the first year of the study, students were given both PBH and

WBH. The researchers believed that this would give them the opportunity to compare the effects of WBH assignments and standard PBH assignments on student achievement (Affouf and Walsh, 2006). The PBH was given via homework text or workbooks and worksheets and was similar to that of the WBH content material but without the algorithmic scrambling. Student results of their WBH assignments were generated by the computer and collected by instructors of the relevant course sections. The collated results were compared with the students' examination scores, after which statistical analysis was performed. Each student's final grade took one of five levels, A–F (with no grade E). The researchers then conducted a one-way analysis of variance (ANOVA) test to see whether the means of the WBH assignments and final examination scores differed significantly among the given grade levels A–F. The independent variable was the final letter grade, and the dependent variables were WBH assignments and the final examination scores (Affouf and Walsh, 2006). The results show that the ANOVA test was statistically significant for both variables in each considered year group. This meant that in each considered year, one, two and three, the p-values $< .001$ (Affouf and Walsh, 2006). The researchers conducted follow-up tests to evaluate the pair-wise differences among the means of the final examination mark and WBH assignment marks in five given grade levels (A, B, C, D, and F) such as Tukey, Student-Newman-Keuls (SNK) and Dunnett's C procedures (post hoc tests). The report of their conclusions was the following: The results of their multiple comparisons showed that the means of the final examinations and student WBH assignment scores were significantly different in each grade level with p-values $< .001$. This meant that the means of final examinations and WBH assignments in the grade level (A) were significantly higher than the means of the grade level (B). The means of (B) were significantly higher than the means of (C) level, and so on down to the last grade level (F) (Affouf and Walsh, 2006, p. 164). This study was one of a few that could compare student mathematics homework performance scores with final exam grades as a measure of the effectiveness of the WBH tool.

In an attempt to improve basic mathematical skills in lower secondary schools in Germany, several schools in 2006 implemented an intelligent Web-based tutoring system called eFit. The researchers aimed to investigate whether eFit was an effective intervention that improved the basic mathematical ability levels of lower secondary-school-aged children. The results showed that children in the eFit group significantly improved their arithmetic performance compared to those children in the control group who used traditional paper-and-pencil methods for homework. The experiment ran for nine months, monitoring the children's mathematics activities inside the class and at home. The children's final exam performance was used as a measure, as to the effectiveness of the WBH tool. The researchers noted that eFit was designed to help eliminate mathematical difficulties and help to train and prepare children for tests. This is in contrast to traditional mathematics instruction and homework given that followed the curriculum content (Graff, Mayer and Lebens, 2008). This was put down as a possible limitation before the study took place. Children received only minimal feedback on their assigned WBH tasks. The class teacher would receive a detailed diagnosis of the performance of each child, and then eFit would tailor learning based on the performance of each child. This personalised learning curriculum would then generate what it deemed appropriate homework for a child to complete at a given level. If the child showed proficiency at the assigned level, the child would be moved on. A quasi-experimental pre-and post-test design was used. After adjustment of the pre-test marks using the analysis of covariance (ANCOVA), a statistically significant difference emerged for the intervention group $F(1{,}191) = 54.89;\ p = .01$. This indicated that the children who participated in the intervention groups and used the tool eFit showed more significant improvement in basic levels of arithmetic than those children assigned to the control group.

The children from the eFit group had a mean score of 73.34 compared to a mean score of 51.02 in the control group. The Cohen's d was 1.17 with an effect size correlation of $r^2 = .25$. This meant that 25% of the variance in the basic arithmetical performance could be attributable to the use of eFit in the experimental group (Graff, Mayer and Lebens, 2008). However, this is without considering any other factors. The researchers noted that a possible reason why the children in the experimental group benefited significantly from the implementation of eFit is "That eFit constitutes a form of instruction which is more interesting and enjoyable for children because it is different from the traditional classroom-based instruction" (Graff, Mayer and Lebens, 2008, p.8). Research observation showed that children who used eFit enjoyed interacting with the tool. Children were also found to refrain from browsing the Web whilst working on eFit, as the tool monitored it. The added advantage for the experimental group was that eFit could be used both in the class and at home. Observation notes indicated a noticeable difference in the classroom behaviour of the eFit experimental group. This was found to be of particular interest to the researchers as lower secondary age pupils in the experimental region's locality were characterised as having behavioural peculiarities and are known for misconduct (Graff, Mayer and Lebens, 2008). Children who used eFit worked with the tool for nine months and arguably had an advantage over the control group in the post-test. This was due to eFit tailoring questions to each child's ability that helped and supported them to perform significantly better in their final exams. The research can be criticised for eFit using the same medium of delivery for the teaching and the testing. This would directly imply that eFit was "teaching to the test" that enabled the students to perform better (Graff, Mayer and Lebens, 2008, p. 9).

2.3.7 Feedback

The construct of feedback is important in this study due to its motivational impact, or lack of it, on student homework completion and performance. Feedback is regarded as information that is provided by a person or agent (e.g., teacher, peer, book, parent, self) that addresses aspects of one's performance or understanding (Hattie & Timperley, 2007). Advocates of WBH has claimed that WBH given to students based on the premise that practicing procedural methods with immediate feedback on your answers is a prerequisite for achievement, and that homework is assigned for this purpose (Feng, Heffernan and Koedinger, 2006; Mendicino, Razzaq and Heffernan, 2009). According to Heffermen (2006), who conducted some studies with the intelligent tutoring system ASSISTment, the faster feedback is given, the more the students will learn. Both Sanchis (2001) and Mavrikis and Maciocia (2003) said that immediate feedback is the most important issue and the "strongest asset in Web-based practice" (Mavrikis & Maciocia, 2003, p.3; Olivier and Snoep, 2004, p.2) after studying the impact of WBH assessment tools. Tang and Titus's (2002) study (mentioned in section 2.2) concluded that well-designed problems given and marked immediately by the WBH tool WebAssign represented a clear favourite over PBH.

According to Thurlings et al. (2013), the characteristics of effective feedback fit into five categories of learning, and they comprise of the following: 1. Behaviourism 2. Cognitivism 3. Social cultural theory 4. Meta cognitivism, and 5. Social constructivism (Thurlings *et al.*, 2013). These categories are said to embody the characteristics that describe feedback and are made-up of the following: task-related characteristics, timing, affective and emotional characteristics and effects on learners (Thurlings *et al.*, 2013). A list of the various forms of feedback characteristics was made and associated with learning theories (see Appendix 30). The related task characteristics should be goal-related, and any feedback given should contain information as to what the next steps are (Black & Wiliam, 1998; Espasa & Meneses, 2010). Scholarly articles from the constructivist point of view suggest that feedback on tasks should be given at the appropriate level where familiarity with the students' working at level is well known and that this knowledge provides the platform for realistic perceptions and beliefs about student performance (Hattie & Timperley, 2007). The timing of feedback from a behaviouristic point of view is that feedback should be given immediately (Goodman *et al.*, 2008; Scheeler, McKinnon and Stout, 2012). Constructivists describe that feedback can be given either immediately or in a delayed manner dependent upon the task that is given (Hattie & Timperley, 2007; Van Der Kleij, Eggen, Timmers, & Veldkamp, 2012). Both learning theories suggest that feedback should be given in a timely manner so that the students' can still remember their actions and the process skills that were used to solve problems. Furthermore, it was suggested that feedback should be given frequently (Black, Harrison, Lee, Marshall, & Wiliam, 2003; Hattie & Timperley, 2007). Both learning theories suggest that the affective and emotional characteristics of feedback should provide students with the opportunity to respond to feedback, engage in dialogue and collaboration with interested parties (Auld et al., 2019; Ong'ondo & Borg, 2011). From the constructivist point of view, affective and emotional characteristics of feedback should be fair, honest and respectful and should also encourage positive motivational beliefs (Li, Liu, & Steckelberg, 2010; Martens, de Brabander, Rozendaal, Boekaerts, & Van der Leeden, 2010). According to Thurlings et al. (2013), behaviourist articles that were reviewed did not consider the effects that feedback had on learners. Nassaji (2011), however, suggested that the important effect of feedback should lead to students correcting their mistakes, thereby improving on their performance. The constructivist view is that feedback effects should be trying to engage students in thinking, self-reflection and finding alternative strategies to address problems (Fund, 2010).

Two forms of corrective feedback were highlighted at the top of the list on Appendix 30, and these forms were called the *Giving Answer Strategy* (GAS) and the *Prompting Answer Strategy* (PAS) (Thurlings *et al.*, 2013). These strategies according to behaviourists and cognitivists, are effective (Goodman *et al.*, 2008; Scheeler, McKinnon and Stout, 2012). In the *GAS* strategy, the teacher or tool provides the correct answer, and in the *PAS* strategy, the teacher tries to elicit the correct answer from the student. The two corrective feedback approaches were investigated in language education, and it was found that *PAS* significantly improved student performance even though *GAS* was used a lot more (Ferreira, Moore and

Mellish, 2007). Other characteristics on the list comprised, were the *Knowledge of the correct Response* (KCR), where learners find out if their answers are correct. Also, *Elaborated Feedback* (EF) that supports the students to engage in self-correction via the provision of help and hint features (Murphy, 2010; Nassaji, 2011; Van der Kleij, Feskens, & Eggen, 2015). Distinctions were also drawn between what is considered to be direct and indirect corrective feedback. Directive feedback indicates an error has been made and the correct answer is then displayed, whereas indirect feedback only indicates that an error has been made (Van Beuningen, De Jong and Kuiken, 2012). Behaviourists tend to agree that feedback is effective when it is immediate and instructional (Werts *et al.*, 1995; Goodman *et al.*, 2008; Scheeler, McKinnon and Stout, 2012). This instructional feedback can take the form of parallel instructive feedback that is given as procedural repetition to remind the learner as to what instruction was given before and expansive instructional feedback that can extend on the instruction given before to advance learners to engage in more complex problem solving (Nassaji, 2011). Constructivists suggest that feedback should be sufficient if it is focused on or related to the assigned task and related to goals that the teacher or student has set. It is also sufficient if the feedback focuses on behavioural procedures that facilitate task completion; has information about student progress; provides next step solutions and targets learning at the appropriate task, process or self-regulatory levels (Hattie & Timperley, 2007; Li, Liu, & Steckelberg, 2010). This self-regulatory process focuses on feedback that encourages student reflection and the reinforcement of learning outcomes (Fund, 2010). Li et al. (2010) found a significant relationship between the quality of student feedback given by the teacher in the form of constructive comments on how to move forward and attain an improved score and the quality of completed student projects.

Skinner (1953) was observing a fourth-grade maths class and noticed that the teacher was trying to teach a group of children who were totally different in terms of their skills, ability, aptitude and learning styles. Skinner found that the students worked hard to find the solutions to several problems before they were given any form of feedback, and rarely were they able to work at their own pace. By creating a teaching machine that broke the information down into small steps and provided the student with instant feedback on their solutions. Skinner (1954) found that by using classic and operant conditioning to teach different students with varying abilities could be more productive and allow for a self-regulatory process (Cofer and Skinner, 1969). Classic conditioning is the response to a stimulus even if it is in the form of a correct answer. Operative conditioning is the step-by-step process that is used in response to the stimulus to achieve the correct answer or the desired behaviour. It was believed that the immediate feedback would stimulate the reinforcement of learning through repetition of procedural methodologies.

However, in later studies associated with constructivist learning, it was perceived that feedback could be of greater benefit to students if they were unable to attain the answer to their maths questions straight away or if it were somehow delayed (Hattie & Timperley, 2007). It was said that "student control of feedback can lead to students not interacting with the material if they can obtain the feedback without doing so. The feedback then lacks value" (Cooper, 1993, p. 12). Given that a lot of the WBH software gives the correct or incorrect response to answers that are inputted by the student into the tool, Cooper also wrote, "while feedback (reinforcement) is an effective tool, the quality of feedback is dependent upon the quality of information that it imparts to the learner; which, in turn, is a function of the diagnostic ability of the program. Feedback mechanisms which only provide a bare-bones indication of correct or incorrect response perform relatively poorly" (Cooper, 1993, p.13).

Kullhavy (1977) studied the construct of feedback and also found that in order for it to be of benefit to any learning process, it is essential that the students were not able to attain the correct answer easily (Kulhavy, 1977). With regard to PBH, Kullhavy felt that if the answer was easily attained, students would merely copy the solution and disregard the mastery involved in attaining it, and that would not lead to learning. With WBH, it was believed that giving the right or wrong answer to student solutions would encourage a trial-and-error type approach to learning that would be disadvantageous to the process of learning (Kulhavy, 1977; Pascarella, 2004).

John Hattie (1999) reported on the various influences on student achievement in a synthesis of over 500 meta-analyses that involved 450,000 effect sizes from 180,000 studies that represented approximately 20 to 30 million students. The analysis covered more than 100 factors that could influence educational achievement such as the type of school, home, teachers, curricular and feedback. In a more detailed synthesis of 74 meta-analyses in Hattie's (1999) database, included some information about feedback that spanned across more than 7,000 studies and 13,370 effect sizes. The synthesis found that the most effective forms of feedback provided cues or reinforcement to learners; and that these were in the form of video, audio, or computer-assisted instructional feedback (Hattie, 1999). Hattie believed that for feedback to be effective, it must reduce the discrepancy between the current and the desired understanding. Hattie said that effective feedback should answer three main questions:

1. Where am I going? Feed Up
2. How am I going? Feed Back
3. Where to next? Feed Forward

According to Hattie and Timperley (2007), effective feedback given at the task, the process, and self-regulatory levels are all interrelated (Hattie & Timperley, 2007). The task level is where students can assess how well they have understood or performed on the task that was set. The process level determines the main skill set that is required to complete the task. The self-regulatory level is a process of self-monitoring, directing and the regulation of actions needed to complete the task adequately. Finally, this can be followed by a self-determining level that evaluates the overall performance positively about the learner. This usually highlights a way forward that would help the learner to achieve task completion to a level that could, at the very least be considered satisfactory (Hattie & Timperley, 2007).

It was perceived that there were several ways teachers could facilitate the process of reducing the gap between actual performance and the desired student goal attainment (current and desired understanding of a topic). This would need the setting of challenging and specific personalised attainment goals. Specific goals in the form of personalised feedback suited to the student's individual needs are more effective than general or non-specific ones. Primarily, this is because they focus on the student's aspiration and attention which allows for the feedback to be more directed (Polly, Lock and Bissell, 2004). The associated feedback is more likely to include information that relates to the criteria for success than more general goals. Teachers can also facilitate the process of developing the student's self-regulatory and self-correcting skills that would support an error detection process. Hattie & Timperley (2007) also concluded that feedback is more powerful when it addresses possible misconceptions or misunderstandings. They felt that this would help build the students' understanding of strategies and techniques that can be used to solve problems. The feedback that was aimed to move students from the task to processing and then from the processing to the regulatory levels was considered to be most effective (Hattie & Timperley, 2007). When immediate feedback is given that is specific to each student's performance, the chances of the student being able to perform at a higher level are increased. Strategies from the teacher or tool can then be used and promoted to help move the student along to perform and solve problems that are more complex (Schmitz and Perels, 2011).

It is essential to discuss the feedback that is associated with the tools used in this study. The WBH tool Myimaths is used in over 750,000 schools around the world. In the United Kingdom, approximately 75% of secondary schools subscribe to the site (Watershed, 2011). Moreover, it is easily accessed in school and at home for most students, and the feedback given to students is consistent in its pure form. The type of feedback generated by Myimaths is open to criticism; as it is not personalised feedback that can be useful in the restructuring of information, especially if that information is domain, cognitive knowledge or skills strategies used to help students improve (Hattie & Timperley, 2007). However, there is the option for teachers' using the tool to write more descriptive, detailed feedback to help students move on. With GeoGebra, the feedback from the tool when constructing shapes via tool features is immediate as they can check their construct in the algebra view window. Students can use the algebra view window and input bar to insert formulae and expressions to construct visual representations (Arbain and Shukor, 2015). Adaptive feedback can be applied through he use of web applications or uploaded by the teacher onto platforms so that students can monitor their performance and see how their constructions and answers have been marked and scored (Gergelitsová and Holan, 2016).

Given the cultural context of the UAE and the family name status that is prevalent throughout the country, which links students to the ruling family, it is crucial to discuss feedback and social justice. Social justice is essential regardless of the contextual issues that arise when giving feedback. A teacher's perception of the class or the type of students' that they teach (good or bad) can have a dramatic effect on their ability to complete set homework tasks and to perform at a satisfactory level. Teachers who lack an understanding of the demographic backgrounds and the history of the students that they teach may not be able to help their students to identify with specific goals and set realistic targets. Specific definitions of social justice may vary, but the underlying assumption is that they all include the idea of accepting, embracing and valuing diversity (Morgan and Watson, 2002; Garii and Rule, 2009). The ability of the teacher to recognise injustice or oppression that is caused by differences is a crucial element when trying to tie the academic content knowledge to the lives of their class students'. Also, feedback that is given to a student on homework may vary given the relationship bond between the teacher and class students. At the secondary level in the UAE, relationships may vary given the status or family name of the student and whether the student is taught at home by the same class teacher. Mathematics homework feedback is motivationally different for all students. However, in the context where apparent disparities and differences occur, it can have very adverse and long-lasting effects if some students perceive it as being unfair. Indeed, for any homework task to be effective and equitable the assessment and feedback given by teachers should be of a similar standard. The lack of consistency in the teacher assessment process when the homework task is more complex makes parity of esteem with feedback difficult. However, there is some evidence that with teacher training and support, feedback given on the standards of student work can be more aligned, equitable and fair (Morgan and Watson, 2002). Teacher training on the use of interactive WBH mathematics tools could support the idea of greater fairness if the student can self-regulate and monitor their progress. If the student can afford any time access to the WBH material content, the feedback given by the tool, no matter how simple, is indiscriminate of the student's background.

Finally, there is the importance of mentioning the assumption that all mathematics homework tasks that are set are accompanied by the teacher feedback within a given timeframe. Of course, this is not the case as there are situations where tasks are set, and no feedback is given. This makes the whole process of setting homework redundant as it serves very little purpose in supporting the individual needs of the student, especially those who are struggling (Mangione, 2008). The reinforcement of learning and the monitoring of student understanding are goals to be achieved when students are given homework, and the failure to give simple, fair and equitable feedback on these goals inhibits and undermines educational attainment (Cooper et al., 2006).

2.3.8 Metacognition

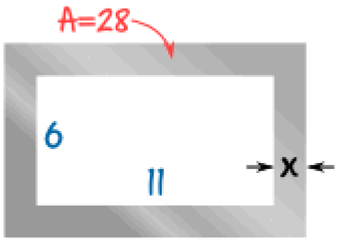
The construct of metacognition is important in this study, as it assesses how learners adjust their thought patterns and mathematical problem-solving strategies to find a correct answer. The previous section on feedback suggested that both the behaviourist and constructivist learning theories place emphasis on the reinforcement of learning once students are aware of their answers or mistakes. The feedback given either confirms the application of correct procedural methods or encourages a rethink of the steps that were used (Hattie & Timperley, 2007; Skinner, 1950). This change in the thought process can stem from the availability of immediate feedback from the WBH tool's facility. Metacognition is a form of "thinking about your own thinking" which is considered to be two-dimensional (Suriyon, Inprasitha and Sangaroon, 2013; Laistner, 2016). The two dimensions are metacognitive knowledge and metacognitive regulation. Metacognitive knowledge informs the learner as to what they know about their cognitive abilities; for example, whether the learner has trouble remembering telephone numbers or the names of people. In mathematics, this would translate into awareness about their knowledge or lack of it with specific topics or processes, such as long multiplication or division, at an early stage of development. The learner can then develop individual strategies to mitigate their perceived deficiencies. In the case of long multiplication, such a strategy might be to break the numbers into separate chunks and use a grid process to solve the problem. Metacognitive regulation allows a learner to control their cognitive thought processes. This dimension of cognition is particularly important in this study, as it enables the student to realise through the availability of immediate feedback that the strategy, they used to solve the maths problem did not work, as it was marked incorrect by the WBH tool. In such a case, a revision of the processes they used is needed (Suriyon, Inprasitha and Sangaroon, 2013).

Perkins (1998) lists the four known categories of metacognitive learners as being: tacit, aware, strategic and reflective (Moore, 2002). He describes the tacit learner as being unable to think about any strategy used for learning; they either know how to do it or not. Learners who are "aware" generally know about their ideas and problem-solving strategies, but their thinking is not necessarily planned. "Strategic" learners try to organise their thinking by arranging or grouping the ideas that could help them to make decisions. These learners try to seek evidence to apply the strategies that would help them to learn. Finally, "reflective" learners are extremely strategic about their thinking, and they can evaluate and reflect on any learning that has taken place (Moore, 2002, p.12). For example, when students are studying probability and probabilistic outcomes of an event happening or not happening, the example of a lottery is often used in grade 10. An open question is given to see how students would deal with the situation: for instance, "How would you decide if it makes sense to play a national lottery every week?" The student would then be given the option to choose which country to play the lottery in and compare that country's system with the system in his or her own country or other countries. This ties in with Perkins's tacit strategic learner that can devise a strategy to solve a problem without the process of thinking or learning.

Metacognition can also be referred to as "self-regulation," and the two terms are often used interchangeably (Pasternak & Whitebread, 2014, p.55). However, recent research has suggested "metacognition" actually refers to the monitoring and the control of cognitive thought processes. In contrast, "self-regulation" refers to the control of all other forms of human behaviour (e.g., social, emotional and motivational) (Pasternak and Whitebread, 2014). The learner's self-regulation involved allows the learner to attain the goals that they have set for themselves. However, the inspired action leads towards "controlled processes" that change the cognitive behavioural patterns of the learner based on the monitoring feedback that was given (Nelson, 1990). According to Nelson and Narens (1990), this behaviour "produces some kind of action at the object-level, which could be (1) to initiate an action, (2) to continue an action (not necessarily the same as what had been occurring because time has passed, and the total progress has changed), or (3) to terminate an action" (Nelson, 1990, p.127). Therefore, the monitoring and the checking process helps the student understand their actions or situation with their completed homework activity. Once this process is over, a decision is made based on the feedback given. This process can help the student to regulate their behaviour and think about accomplishing set goals and targets or at the least task completion. In this way, the student can monitor and manage their progress far better than by being wholly reliant upon their teacher's feedback. The feedback with PBH usually comes after a few days at a minimum, and in most cases, it arrives long after the student can remember the assigned task. In some cases, the feedback is not even given, or it is overlooked. Therefore, metacognitive practices in this research with WBH may make a somewhat unique contribution to learning that exceeds the cognitive limitations students may have with PBH. Research evidence has indicated that metacognitive practices have helped students with their learning and improved academic achievement across a range of "ages, cognitive abilities, and learning domains" (Sommerville, 2015, p. 2).

Like most areas of research, however, this one has limitations. It is unknown as to how transferable metacognitive skills are in relation to the thinking that is done given the feedback for a particular type of question in mathematics. For example, a mistake a student makes in solving a quadratic equation can be spotted and rectified by adjusting a procedural element. However, if the same question is presented differently, for instance, depicting a real-life situation (as in Figure 1), it remains unknown whether the student could adjust, reflect and solve the problem.

A company is going to make frames as part of a new product it is launching.



The frame will be cut out of a piece of steel, and to keep the weight light, the final area should be **28 cm²**, and the inside of the frame must be **11 cm by 6 cm.**

What should the width ***x*** of the metal be?

Figure 1. Quadratic real-life expansion problem (Schneider and Artelt, 2010)

Despite limitations in the field of metacognitive development. It is an area that needs to be investigated practically in further studies to find out two things. The first is the development of student awareness when using a particular strategy or method, and the second is the transfer of those awareness-development strategies to be able to answer more complex (real-life) problems.

2.4 Summary

The literature review tried to give some insight into why, even with the changing historical and ideological contexts of homework, it can still be used as a vehicle to improve the teaching and learning of mathematics. Despite the political, economic and social debate as to whether homework is good or bad, studies have concluded that students derive key benefits if they can engage in quality homework tasks (Cooper et al., 2006; Gill & Schlossman, 2000; Murray et al., 2006). What constitutes high-quality homework, however, has remained open to debate and scrutiny (Cooper & Valentine, 2001).

The review of the literature suggests that mathematics WBH has been offered as a possible solution to problems associated with traditional mathematics PBH. Problems of PBH concerning student completion rates, engagement, anxiety, performance, motivation and their perceptions of method delivery type have been well documented (Hodge et al., 2009; Nguyen, Hsieh, & Allen, 2006; Nguyen & Kulm, 2005). This literature review tries to highlight what is known in the field of WBH studies and the legitimate and the perceived successes it has had in comparison to PBH. The aim of this research study was not to replace PBH, but to offer WBH as a supplementary alternative and to evaluate its impact on the possibility of improving student homework completion rates and performance in mathematics. Again, what constitutes improved mathematical performance is open to scrutiny and debate, but this review and this study conducted in the UAE tries to compare WBH and

PBH scores in control and intervention groups to see if there are benefits to be attained as in other studies (Bonham et al., 2003; Demirci, 2010; Hodge et al., 2009; Khanlarian, 2011; Nguyen et al., 2006; Nguyen & Kulm, 2005).

Several constructs could affect student performance when students' attempt to complete set homework tasks. This study looked at some of the constructs that could enhance or inhibit student mathematics homework completion and performance. The list is extensive but not exhaustive and includes homework, student-self-efficacy, maths anxiety, the amount of parental involvement, student motivation, the effectiveness of the technology, feedback and the benefits of multiple homework submissions. Besides, the critical inclusion of metacognition and whether student perceptions are in line with the hypothesis that WBH improves mathematics performance was also considered. These themes emerged from the literature as some of the most important constructs in comparative studies of WBH versus PBH to address (Bonham et al., 2003; Hodge et al., 2009; Jones, 2008; Khanlarian, 2011; Nguyen et al., 2006; Nguyen & Kulm, 2005; Pascarella, 2004).

The difference between the results from the studies reviewed could be due to the different types of WBH tools used. Some tools give more extensive feedback to students, while others just marked the answer right or wrong and displayed the correct answer. Some tools further provide help and assistance, support lessons and tutorials. One consistent approach used in the studies reviewed was to allow multiple homework submissions. This approach may have encouraged a trial-and-error type method from students in some studies, depending on the type of feedback given by the tool (Pascarella, 2004). However, a strong argument for this approach is that it may allow students time to revise their thought processes and re-attempt the mathematical processes and procedures required to attain the correct answer and achieve an improved homework score (Kaune, 2006; Schmitz and Perels, 2011; Laistner, 2016). The actual number of homework attempts may have varied from study to study, depending upon the criteria for homework submission that was set. Some teachers may have set limits, while others did not. Some studies may have been able to control this feature using the tool, others not.

The areas considered in this research included the political, economic, social and cultural environment where the research took place. When reviewing the literature from Western socio-economic and political backgrounds, this was, to some extent, addressed comparatively. This study contributes to the body of knowledge by examining some of the effects of student interactions with two WBH tools, Myimaths and GeoGebra in comparison to traditional mathematics PBH. The tools were used to support the Abu Dhabi Education Council (ADEC) curriculum content material, and they provided immediate feedback to students who interacted with the technology on their performance. I deliberately chose the tools used because I believed it fitted both the traditionalist and the constructivist approach to learning that adds even greater value to this research process. It is unclear from the research literature on WBH versus PBH studies if two tools that are associated with different approaches to learning have ever been adapted and used to facilitate a cultural context like that of the UAE. The problematic issue with the lack of homework interaction provides strong reason to find out if WBH could be used to improve rates of homework completion and performance.

The next chapter in this study provides the methods used to discover whether students in the UAE interact more with WBH than they perhaps do with PBH. Also, if the methods used would determine if the intervention with WBH improved rates of homework completion and homework scores. Finally, it could also tell us if prolonged interaction with WBH by students could help them identify differences between delivery methods in terms of the benefits in learning mathematics. These benefits would be a measure of student perceptions about their learning with WBH and PBH.

Chapter 3 – Methodology

3.1 Introduction

This study aimed to compare mathematics WBH with mathematics PBH in the context of the UAE, where there are reportedly low levels of student self-efficacy and homework completion (Afari, Ward and Khine, 2012). This study reviewed previous mathematics WBH and PBH studies that looked at the use of WBH tools and their tasks in comparison to traditional PBH tasks (Bonham et al., 2003; Demirci, 2007; Dufresne et al., 2002; Jones, 2008; Khanlarian, 2011; Nguyen & Kulm, 2005; Tang & Titus, 2002). These studies helped in the design and framework of this WBH versus PBH study. However, to my knowledge, none of these previous studies used WBH mathematics in an unfamiliar setting like the UAE.

The primary purpose of this study was to evaluate mathematics WBH tools in comparison to that of traditional PBH to see whether it could enhance homework completion and performance. In using technology, this study considered whether the students in the UAE Emirate of Abu Dhabi interacted more with their homework (measured by homework completion) and could identify differences between delivery methods in terms of benefits (measured by student perceptions in surveys and at interviews).

The arrangement of this chapter is in sections; it first gives the research questions (RQs) and the null hypotheses and then considers the appropriateness of the research design. The setting and participant sample then follows. Then, the instruments used for this WBH versus PBH study are described. Also, a description as to how the data were collected, processed and analysed followed. Finally, due regard and consideration were given to the possible ethical considerations that the study could encounter. A final summary of the chapter then follows this.

3.2 Research Questions

1. Do students interact more with WBH than with PBH?

2. What are student perceptions of their learning with WBH and PBH?

3.2.1 The Null Hypotheses

This study tested the null hypothesis from the leading primary research questions (RQs):

Null Hypothesis 1

Students do not complete more WBH than PBH

3.3 Research Design

This study used a two-group control pre-test, post-test design to answer the RQs (Cresswell, Ivankova and Stick, 2006). The two-group control pre-test, post-test design is where one group is subject to control (PBH), and the other group is subject to an intervention (WBH). The PBH control group was given homework in the usual, traditional manner via a maths homework book activity or worksheet, and the WBH group was given their homework via the use of Myimaths and GeoGebra. A two-group control pre-test, post-test design was used because it was not possible to select the schools in the UAE randomly. Schools were selected based on a convenience sample. However, student participants were randomly assigned to groups (WBH or PBH) from within their selected school and grade. A pre-test, post-test design was used to answer the RQs with better effect, as it would allow for possible changes in participant behaviour over time (Cresswell, Ivankova and Stick, 2006). These changes were associated with the study participants rates of homework completion, performance and perceptions about their learning with Web-based and PBH. Student perceptions about learning mathematics was associated with whether WBH is a more suitable delivery method than PBH given the study's identified problems and cultural context. The design was supported by conducting a student survey and semi-structured interviews to gain insight and considered valued perceptions of student experiences and interactions with different homework-delivery methods. Four schools were involved in the study, school A and B for boys and school A and B for girls. These names were chosen for equitable reasons and to give parity of esteem. In each school, there were control (i.e., PBH) and intervention (i.e., WBH) groups. PBH and WBH were given simultaneously, and each time students had a week to submit their respective homework tasks and receive feedback. This process was repeated 17 times.

The groups were then assigned the same task that they did for the pre-test, for the post-test. However, the intervention group (WBH) would have their questions algorithmically scrambled when using the WBH tool Myimaths. The homework task was the same, but the numbers were different. The procedural processes required were the same as in their WBH pre-test. The study used data on student performance scores from the two homework-delivery methods (WBH versus PBH) set over three years. A construct design was necessary to support this study as it looked at several variables that could affect homework completion and performance. The constructs were homework and its completion; the self-efficacy levels of the students; mathematics anxiety; feedback and metacognition. These constructs were pooled from the review of the literature that indicated a notable effect on homework completion and performance. Finally, student perceptions about their learning of mathematics with WBH and PBH were investigated via a survey. This design would help to determine whether the treatment group (i.e., with WBH) had any effect on student levels of self-efficacy that led to greater interaction with the tools and improved homework performance (Cohen, Manion, & Morrison, 2007). It was assumed in this study that the construct variables listed above would have both positive and negative effects on the measure of homework interaction. The measure for interaction was chosen to be homework completion as it addressed the problem associated with the UAE context (lack of homework completion).

The WBH and PBH tasks were aligned to the mathematics curriculum learning objectives and were given to reinforce learning (Marzano and Pickering, 2007; Mangione, 2012). To try to raise homework completion rates, WBH was introduced and used to support and track student scores on homework tasks. Teachers had to be trained on how to use the tools to support their students learning by being able to set WBH for their classes and to gain access to student WBH scores. Class time was allotted both to help support the teacher and to introduce the students to the WBH tools. My role as the Education Advisor was to train the teachers to train the students on how to access and use the WBH tools to support the learning process. The role of the teacher was to use the tools to support their classroom teaching and to help support the reinforcement of learning through mathematics WBH tasks. The WBH and PBH tasks that were given in the study were similar in content, including the number of problems given and their level of difficulty (see Appendix 2). The assumption was that this methodological approach would help to not only improve homework completion rates but improve homework performance scores.

3.3.1 Pre-test, post-test design explained

The two-group pre-test, post-test control group design was used in this study. Students were randomly assigned to their groups after selecting the number zero or one from a basket. The rationale included the assumption that average class sizes were approximately 30 students to a class. Therefore, the aim was to have a balance of 15 students in both the control (PBH) and intervention (WBH) groups. The students that selected a zero were assigned to the control group and receive PBH and those that took the number one were assigned to the intervention or treatment group and would receive their homework via the WBH tools Myimaths and GeoGebra (GeoGebra at selected times). Both the control and the intervention groups were pre-tested and post-tested, with the main difference being that one group was subject to the administered treatment, which was WBH. The students assigned to the intervention group were given WBH in both pre-test and post-test and similarly students assigned to the control group were given PBH in both pre-test and post-test. While taking the pre-test, students were not expected to know the answers to all the questions, and it was more than likely that they would have had to build familiarity with the language style and what would be expected of them. However, it is fair to say that an expected assumption would be that students would utilise previous knowledge to predict or attain rational answers. When taking the same test called a post-test after an initial period (in this study it was a week), the expectation was that students should be able to answer more questions correctly based on an increase in their familiarity with the technology tool and the PBH task. As a result, the students should improve mathematical procedural skills and understanding that would lead to an improvement in their performance (Hartas, 2010).

The two-group pre-test, post-test control group design allows me to compare the final post-test results between the two groups, thereby giving an idea of the overall effectiveness of the intervention or treatment (Dimitrov and Rumrill, 2003). Moreover, it shows how both groups changed from pre-test to post-test, whether one, both or neither improved over time. If the control group showed a significant improvement, then I must try and attempt to uncover the reasons behind this. Besides, the design allows for several analyses to take place to help get rid of so-called "third variables," which are those the researcher failed to control (Cohen et al., 2007, p.139). These variables include possible effects on the dependent variable (homework score) and maybe part of the constructs looked at in this study, such as motivation and feedback. However, this design is said to have strong internal validity because the pre-test tries to ensure that the groups are equivalent.

3.3.2 Between the pre-test and post-test

The provision of feedback to the PBH group was a key reason for the timeframe of one week between the pre-and post-test. Feedback given from Myimaths and the GeoGebra WBH tool was immediate in the case of Myimaths and close to immediate with GeoGebra. Due to the nature of the WBH tools used and the provision of immediate feedback, this allowed for an attempt, re-attempt cycle that was very difficult to near impossible to stop (discussed in the limitations). It was an assumption that students during this time would adjust their thinking by using help features, interacting with their peers, reviewing lesson notes before attempting the post-test homework task. The magnitude of this attempt, re-attempt cycle cannot be determined as there were no instructions given to the teachers to review the WBH. However, the natural assumption made would be that through the reinforcement of learning objectives in mathematics class allocated time, it would improve student homework performance and scores.

The PBH feedback given was personalised and structured to help the student progress by attaining more marks. Students would be given feedback during class time, and the papers returned to the teacher. By doing this, the students would not know what to expect from the post-test, as they were not told that the post-test would be the same as the pre-test. Notably, some students would, of course, prefer the feedback given to them by the teacher as opposed to a tool that is just displaying the right or wrong answer. Any teacher or class review of the homework topic in preparation for student investigative assessments helped to support student growth, and for sure in individual schools and year groups, this would have been the case. This decision was based on the class teacher's experience and where they were with the curriculum content and in what order they delivered it. The feedback given to all students (PBH and WBH groups) was also to help facilitate the reinforcement of learning objectives that were to foster student motivation in preparation for regular continual assessment activities such as tests, investigations and explorations. Uniformity was achieved with the dates and times of the pre and post-test for all participating schools, but not all schools were at the same point with the curriculum content material. The dates and times for the homework tasks are given in Appendix 2.

3.3.3 The notion of group equivalence

Equivalence of group designs are not easy to attain, and heated debates often arise when considering the extent to which groups are equivalent (Hartas, 2010). The comparative two-group control design used in this study is considered to be strong as the pre-test measures are used to determine the changes that took place during and after the intervention. Equivalent experimental and comparative groups help to control the extraneous variable factors and helped me to draw possible conclusions that the observed differences were due to the intervention (Hartas, 2010). To ensure that fundamental differences due to extraneous factors are small, proper sample size and random assignment to the groups were necessary. Minimising extraneous factors would help to eliminate the effect of post-intervention group differences that are caused by the pre-intervention group differences between the groups that maybe mistakenly understood as being caused by the intervention. Group differences could have arisen as a result of students trying to build language familiarity or an understanding of how questions were structured. The students that were selected to be a part of the study were introduced to WBH before the pre-test. Even though instructions would have been given to students about their behavioural integrity, it is sensible to consider that some students would have interacted with the tools at different levels and developed proficiency with tool usage between the stages of pre-and the post-test. Another thing to consider is the ability levels of the students assigned to either group. If a disproportionate number of students with a high ability level were in either group (WBH or PBH), it could potentially confound the results. A group concentration of high ability students can contribute towards ceiling effects and abnormal data distributions that could lead to Type I and Type II errors. A Type I error is where we think that there is some relationship or an effect between the groups, but there is not. This leads us to incorrectly reject the null hypothesis in favour of the alternate hypothesis. A Type II error happens when we think that there is no relationship or effect between the groups, and there is. This leads us to accept the null hypothesis incorrectly. A Type I error is considered to be worse than a Type II error as we indicate that there is a statistically significant difference between the groups. In reality, there is no relationship between the groups (Hartas, 2010).

3.4 Setting

This study took place in UAE single-sex secondary schools in the Emirate of Abu Dhabi. The Emirate of Abu Dhabi was chosen to help inform the education reform programme in Abu Dhabi and the broader social research community. Four schools were chosen through convenience sampling through my working relationship with the Education Council. Two boys' schools and two girls' schools were selected in the city of Al Ain, Abu Dhabi. Both boys and girl schools were selected to try to represent the school population in Abu Dhabi. Although in using this approach, one might expect underlying gender variables to emerge in the study results, gender comparison is not part of this study due to ethical concerns. The appropriateness of comparing schools and gender in Abu Dhabi is culturally sensitive and risky as it can offend. This study does address some of the effects of WBH on selected participants, and these effects may be due to gender differences, but this cannot be confirmed. The data collected was carried out over three years and involved nine trimesters of curriculum study. The government of Abu Dhabi has spent considerable amounts of money investing in new technology for the schools and facilitating Emirate homes with Internet access. The Education Council is now at the stage of trying to put into practice, the greater use of computer technology in their cycle one, two and three schools. Cycle one schools are primary schools that comprise of students aged between five and 11, and cycles two and three refer to the secondary school age range, namely 11–18; this study examined schools only in cycles two and three. Homework is a requirement in Abu Dhabi schools, and mathematics homework tasks are supposed to be given once a week. However, homework is not part of the continual assessment grades for students, and homework completion in Abu Dhabi schools has been a continuous problem, attributed to inadequate levels of student self-efficacy (Afari, Ward and Khine, 2012).

Before the start of this research, homework setting and completion in the selected schools was almost non-existent. Education advisors who conduct formal and informal lesson observations of mathematics classes in schools, a process of which I was part, noticed this absence of homework in the schools. The teachers' main explanation for the paucity of mathematics homework was lack of teacher confidence in the self-efficacy levels of their students. I noticed that several schools have interactive whiteboards in their mathematics classrooms, but any form of interactive Web-based learning (WBL) was rarely used. The lack of WBL led me to introduce it to the class and to support that learning by using interactive WBH tools. Both teachers and students in my assigned ADEC schools used the tools. Initial reactions were positive, and it inspired a pilot study in the 2012–2013 academic year to test the effect of WBH in comparison to that of traditional PBH in Abu Dhabi Schools. It is important to note that the pilot study was conducted in different schools.

3.5 Participant Sample

The data gathered in this study came from UAE students enrolled in government schools in Abu Dhabi. The students were all Arab, with a mix of both local UAE nationals and Arab expatriates. English was their second spoken language, and the medium of instruction was supposed to be in English up to grade 9. However, often the medium of instruction was in Arabic, as the year 10 to 12 curriculum was exclusively delivered in Arabic. Students started WBH in the autumn of 2011, and the study concluded in the summer term of 2015. Classes in year 7 through 11 were selected at random to go through the four mathematics strands associated with the mathematics curriculum in Abu Dhabi. For these year groups, control (PBH) and intervention (WBH) groups started with the tasks that were assigned over the three years. The total population of the Boys School A and B was 543 students and 438 students, respectively. In the Girls School A and B, there were 584 and 493 students, respectively. Both the control and intervention groups consisted of students enrolled in the common cycle age range from grades 7–11.

Due to my work as an Education Advisor for the ADEC, I had access to selected boys' secondary schools. However, in the selected boys' schools, I had minimal experience or knowledge of their teachers or participating students. I was able to select the girl schools because of my professional working relationship with a teacher in one of my assigned ADEC boys' schools who knew female teachers who would be interested in using the WBH tools. Male access to girls' schools was difficult and restricted due to cultural and religious issues. It is important to note that this teacher's school was not a school in the sample selection process. The population (*N*) of the two boys' schools and two girls' schools was approximately 2,000 students from Year 6–12. Year groups 6 and 12 were not used in this study because of their differences from other year groups curriculum-assessment procedures. The year six curricula had just been newly implemented, and year 12 was delivered exclusively in the Arabic language. The elimination of these year groups reduced the participant sample within the schools by approximately 250 students. Therefore, a better approximation of the total population size (*N*) would be 1,750 students. I used a sample size calculator to determine the possible number of observations needed for the study condition to estimate the variability of the phenomena at a confidence level of 95%. The calculator gave the value of 316 or more measurements.

A total of 540 students from year 7–11 were selected to be part of the total sample (see Appendix 1). Each class of students took a piece of paper from a basket with the numbers zero or one written on them. Students took these numbers without replacing them and were asked to keep them. At a later stage, their class teacher would inform them which number coincided with the control or intervention group. Class sizes were not expected to be any bigger than 30 pupils, so 30 pieces of paper with the numbers zero or one on them (15 of each) were appropriate for each chosen class in the four selected schools. The method chosen was to obtain, as fairly as possible, an equal number of participants in each of the control and intervention groups. The sample was stratified by school, Boys A and B and Girls A and B.

Appendix 1 breaks down the distribution of students selected to the control (PBH) and intervention (WBH) groups. The stratified sample of school and year groups show Boys A and Boys B as well as Girls A and Girls B. The total (*n*) represents the numbers of students randomly selected from the year group and school assigned to the WBH and PBH groups.

Since the schools chosen were single-sex schools, concern about the balance of gender among participants was limited for two reasons. First, as mentioned earlier, this study does not investigate gender differences regarding homework delivery methods. Secondly, the data concerning the ratio of girls to boys in UAE schools is unknown due to rural and cultural traditions of not sending young girls to school and involving them in the process of education. The selected groups were tracked over the research period of three years to assess whether the WBH delivery method had helped to improve student rates of homework completion and performance more than that of PBH. The task section in Appendix 1 indicates the number of pre-and post-tests conducted throughout the study. For example, in year eight, a total of six pre-and post-test WBH and PBH tasks were completed, three in the boys' school and three in the girls. Sticking with the grade 8 boys, if we work across the rows, in the column marked with a (*n*), is the total number of students sampled per school. In Boys A, 21 students were randomly selected; 10 were assigned to the control group (PBH), and 11 were assigned to the intervention (WBH) group. The date of the pre-test is written between the total number of students selected and their equivalent breakdown in the control and intervention groups. The post-test date follows with the number of students who completed the set homework task again. These students were those selected for the pre-test homework task. The numbers in the post-test homework task do not always correspond with the numbers that completed the pre-test. Some students, for whatever reason, did not complete the same assigned homework task for the post-test. These are the same set of students from the original 21 students selected from Boys A. This missing data was allowed and acceptable, as students' who were selected to be involved in the study could opt-out at any stage of the study if they felt the need.

A student survey was given out to a sample of students at two stages: the first after a pilot study in different schools in December 2012, and the second towards the end of the main study. The pilot study survey was given to two different year groups in the mathematics department of two selected schools (a boys and girls school). In the pilot study two year 8 and 11 groups were chosen from boys and girl schools, respectively. A 23-item survey was trialled with 141 students to identify any misleading, ambiguous or mistranslated items. Of the 141 students randomly selected who took part in the survey, 87 were boys and 54 were girls.

The main study student survey consisted of 25 items and was available for students to take Online; however, most of the surveys were completed on paper in the summer of 2015 (see Appendices 16 & 17). Manually completing the survey was more convenient for the students, as they could seek support with the language used in the survey, even though it had been translated from English to Arabic. There were 204 respondents from across the year groups 7–11, 124 male and 80 female participating students. This sample size calculated was on the basis that there were 540 students involved in the pre-and post-test WBH versus PBH study. Therefore, the number entered in the calculator for a sample calculation was 540, and the number of participants required to be involved was 225. However, 204 students completed the survey out of a possible 230 that were randomly selected. This amounted to a 5.42% margin for error. The selection does fall below the required sample size for a 95% confidence interval; however, given that the number of survey respondents is close to the acceptable sample size recommended, it can be considered an acceptable sample size (Cohen et al., 2007; Lenth, 2007).

In the summer term of 2015, a random stratified sample of 24 (12 boys and 12 girls) students were selected to be interviewed. These were students who had experienced both types of homework methods (WBH and PBH). Students were from the year groups 8, 9, 10 and 11, and their selection was important in terms of their comparative experiences, interaction and knowledge gained throughout the study. It was also essential to make sure that part of the stratified sample included students who interacted with both the Myimaths and the GeoGebra WBH tools. Students were contacted by phone by their respective class teachers and asked whether they were willing to participate in the interview process. The method of contact tried to ensure students of anonymity and confidentiality about the data collected. Students were informed at the interviews that the data would be recorded and later transcribed. The recorded interviews and files were transferred to a personal computer for transcription. The information on the computer was password protected. The names of the students were replaced with code numbers that identified the school and gender of the student. Each school had six interviewees, so in the Boys A school the codes were given BA1, BA2, BA3. Similarly, in the Girls School B, the codes were given GB1, GB2, GB3. The sample was chosen to produce a group of students involved in the two-group control design who were representative of the population being studied. Sample size calculations for the interviewed students was difficult to apply as the required number would have to be based on the number of participants involved in the study design that had experienced both homework delivery methods. Twenty-four students for the interviews fall short of the power calculation, but it is a sample that was chosen, based on convenience and access. Concerning interview sample size within qualitative research, it is considered typical "to study a few individuals or a few cases" (Cresswell, Ivankova and Stick, 2006, p.209).

3.6 Instrumentation

The instruments used in this study included pre-and post-test mathematics homework tasks given via PBH, Myimaths and GeoGebra WBH. Also, a paper-based survey and a semi-structured student interview were used to find answers to the research questions: (i) Do students interact more with WBH than with PBH? (ii) What are student perceptions of their learning with WBH and PBH? The student survey was given in two stages. The first was after the completion of a pilot study on WBH versus PBH in the fall of 2012. The second was after students involved in the study had been allowed to develop a better understanding and more familiarity with the WBH tools towards the end of the study. The pilot study survey was used as an informative instrument to develop the survey for the main study. These instruments were to gather student perceptions of homework delivery methods, after their pre-and post-test experiences. The survey approach used helped students express, to some extent, their feelings about WBH and PBH that could later be supported or rejected in follow-up student interviews. Culturally, it is not easy for Emirate students to express themselves in a manner that is unfavourable to innovative or new experiences. Getting them to speak openly about their perceptions and feelings towards topics deemed semi-political is often a daunting task, for fear of repercussion or reprisal (Kargwell, 2012).

3.6.1 Instructional and Curriculum Format

Sixteen class teachers taught the four ADEC mathematics curriculum strands (number, algebra, shape, measurement and data) in the four schools over three years. Class teachers were all expatriate, of Arab origin, which helped with the consistency, continuity and student understanding throughout the study duration. Therefore, the teaching style, delivery, instruction and grading throughout the study remained relatively consistent in terms of the pedagogical approach adopted by each class teacher. However, the textbooks and materials used did change, along with the curriculum content and assessment procedures. This change caused much confusion and anxiety amongst staff and students. Confusion and anxiety were kept to a minimum by keeping the homework procedures similar to those of previous years. The Myimaths and the GeoGebra (WBH) tasks used were given to support and reinforce the learning that took place in the classroom.

The curriculum content was taught using student workbooks from Pearson Education. The curriculum books are written explicitly for the UAE context and updated from *Signpost Mathematics (Pearson Education) 2012–2013* to *Mathematics for Life 2014–2015*. The ADEC made these changes. There were thus some inconsistencies in the curriculum format over the nine trimesters. The change in student workbooks was made primarily to assist accessibility in the English language, as well as the conceptual understanding and promotion of mathematics in a real-life context. Six periods of maths per-week were given to students in year 7, 8 and 9. For year 10 and 11, mathematics was given ten periods per-week. Each period varied from 45 minutes to an hour, depending on the trimester and the school timetabling. Since the scores were not part of the final cumulative continual assessment score, any exclusion of mathematical content material was considered insignificant. Therefore, the main variables to consider in this study is the homework delivery method of intervention (WBH) and control (PBH), and the associated student scores.

The structure of curriculum content and assessment is important in this study as we have to be able to follow and support the teaching and learning process according to the pacing schedule issued by the ADEC. So, all assigned homework tasks must adhere to the curriculum content material that is taught and assessed. The curriculum structure in cycle-two schools (i.e., years 6–9) uses one process strand, so-called working mathematically, and four content strands: number, patterns and algebra, measurement and data, and space and geometry. The process strand incorporates the notion that "Students will develop knowledge, skills and understanding through inquiry, application of problem-solving strategies including the selection and use of appropriate technology, communication, reasoning and reflection" (ADEC, 2014, p.7). In grades 6–11, the curriculum content is broken down and assessed in three areas: continual assessment, external measure of student achievement (EMSA) and a final exam. In year 8–11, this breakdown comprises two explorations and one investigation in the first and second trimesters, and it involves an investigation, exploration and test in the third trimester. The continual assessment accounts for 60% of the curriculum content, EMSA, 10%, and the final exam in trimester three, 30%. In the Abu Dhabi School Model (ADSM) in grade 7, the continual assessment accounts for 70%, EMSA 10%, and the final exam, 20%. Each trimester is broken into a recommended class period time allocation. For example, in the ADSM grade 7, the first trimester has 84 class periods, the second trimester, 69, the third trimester, 54. Each trimester covers the content strands in various orders.

3.6.2 Web-based Homework Tools

There have been some irregularities in the results of previous research studies trying to determine the effectiveness of WBH tools (Alexander, 2013). In fairness, this may be attributable to the different capabilities of the tools used. According to Alexander (2013), when assessing why some tools are considered more effective than others, researchers must give a detailed description of the tool used and the subsequent feedback from student and teacher interaction. This feedback could pave the way for the possible identification of specific trends in tool functions that would benefit both software designers and educators. The following is a description of the WBH tools used in this study.

Participating students who were randomly assigned to the WBH group and used Myimaths received a percentage score along with a traffic light system of green, amber or red to indicate a competence level. This feedback system used measured whether the student should attempt the homework again and look through the lesson notes provided by the tool. Once students complete the homework, they can click on a "checkout" bar that is on the screen or upload their homework to a website for teacher feedback. Student scores are recorded and then sent to a database that can be accessed by both the student and their class teacher immediately upon completion. If students are dissatisfied with their performance, they can attempt the homework task as many times as they like before the deadline, and their most recent mark is recorded by the tool as their standing result. This method of allowing multiple homework submissions was because it was similar in approach to that given in previous studies (Bonham et al., 2003; Demirci, 2007; Hodge et al., 2009; Nguyen et al., 2006; Tang & Titus, 2002).With the GeoGebra tool, students uploaded their completed homework task to the Classtell.com website. Automatic notification of any student upload went to the respective class teacher. The teacher would then provide feedback on student work. The feedback given was not immediate, but it was timely.

3.6.3 Myimaths

Irrespective of the type of homework delivery method, homework problems were given to reinforce learning objectives and key mathematical processes required from the curriculum content material. Myimaths, considered to be an Online textbook that supports the United Kingdom and the international schools' curriculum is a subscription-based website for schools that boasts "Lessons", "Boosterpacks", "Online Homework", "Revise it" and "Games" for students to interact with (Nicholls, 2010). Web-based homework, referred to as "Online Homework" on the tool, was used to complement the lesson activities. In this study, no distinction was drawn between WBH and "Online Homework", as they are both accessed via a Web-based browser. Myimaths is not an intelligent tutoring system that analyses student responses to provide the student with personalised questions, appropriate feedback on method layout and help. Instead, Myimaths is a basic tutoring system that provides immediate marking on the tutorial content without the personalisation of the content material from the application. However, the content material can be personalised by the student's teacher after observing a task completion or whatever the teacher feels is an area that needs to be addressed after assessment for learning strategies (AfL) has taken place. In Figure 2, you can see that each lesson has a national curriculum target level attached to a corresponding homework activity that I have described as a WBH facility that supports the lesson content.

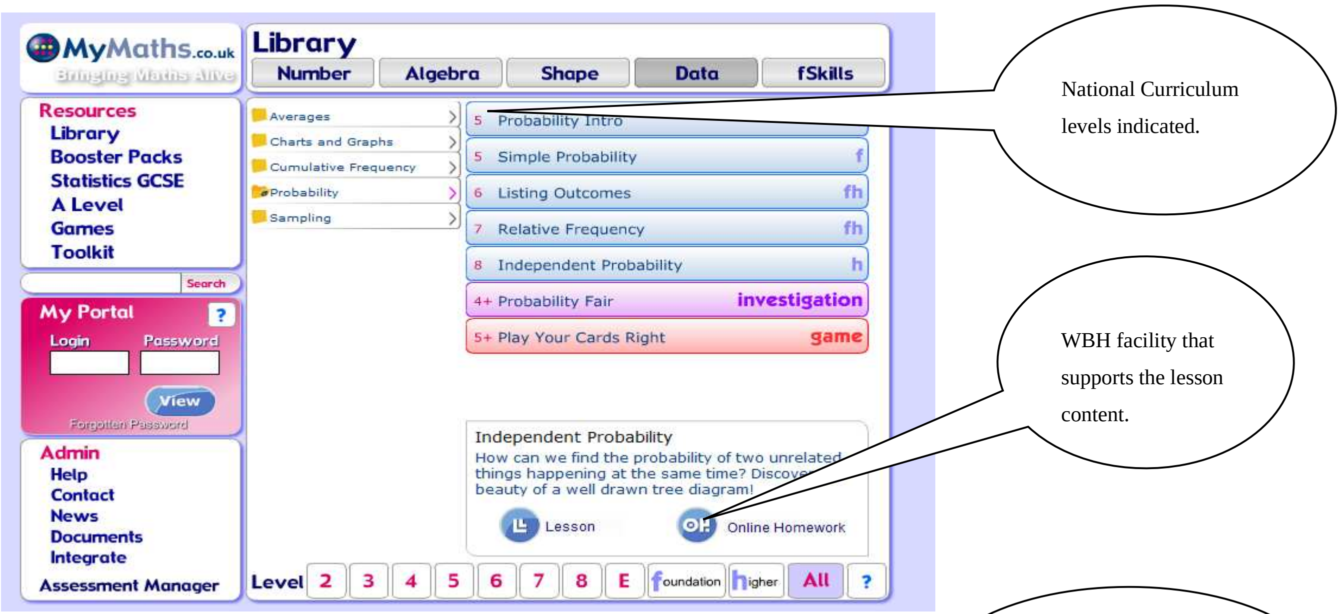


Figure 2. Screenshot of a Myimaths data menu page

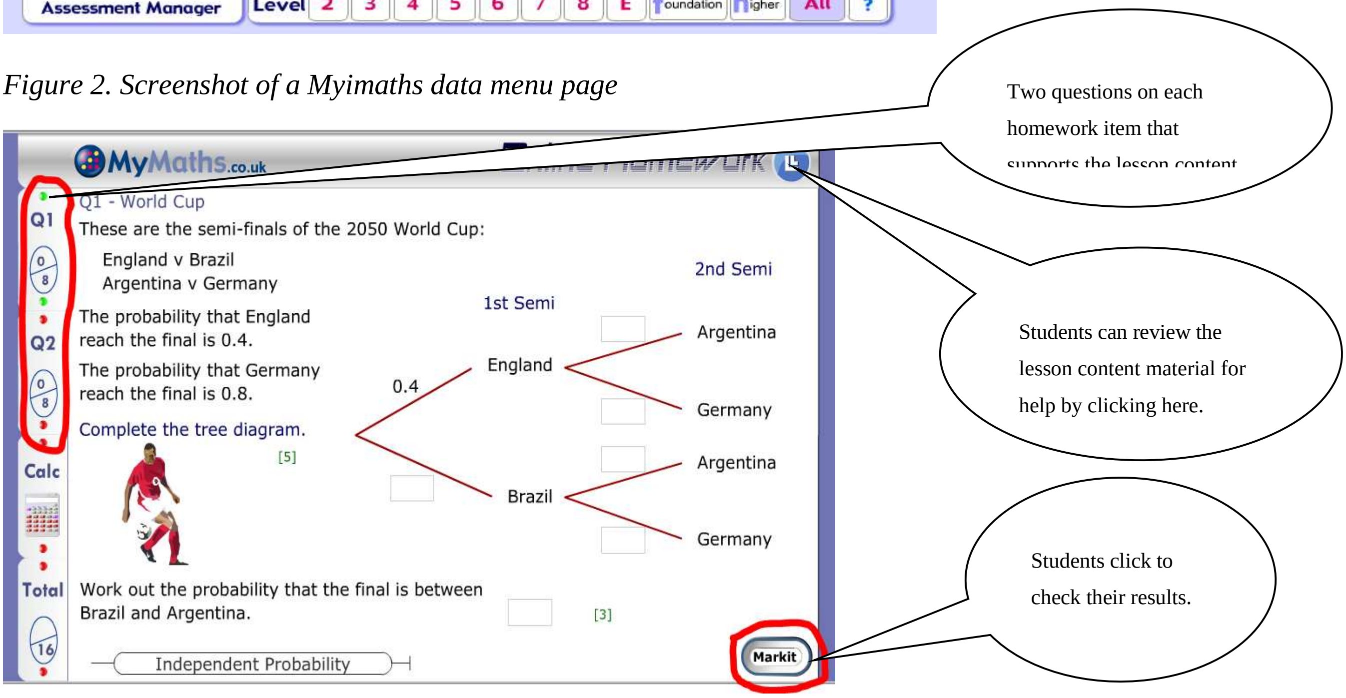


Figure 3. Myimaths Web-based homework example question.

Figure 3 is highlighted in red to mark two sections of an Online homework task. Each homework task has two main questions (Q1 and Q2) on the left-hand side of the page. On the bottom right of the screen, students were able to get immediate feedback on their answers by clicking on "Markit". The feedback given was a tick if the answer was correct, or the correct answer is displayed. Once the student has completed the task, Myimaths records the result onto a database system that can be referred to as a "pupil record system", as described by Wood et al. (1999, p.92). The marks given to pupils are immediate and kept as a record of scores for completed work. The teacher issued the assessed work for this study with my support. The WBH scores are given in a "traffic lights" formation. A red is issued if the student achieved less than 50%, orange if between 51% and 74%, and green if 75% or above. This "traffic light" system of feedback is automatic upon completion of the homework task. It is in line with Assessment for Learning (AfL) strategies issued by the Department for Children Schools and Families (DCSF Department for Children Schools and Families, 2009, p.17). Questions from the Myimaths WBH tool's bank are scrambled algorithmically. The algorithmic scrambling means that each pupil answers questions based on the same topic, but the problems are numerically different. In the homework tasks, students were allowed the opportunity to interact with the homework content through various communicative methods which included their friends and family members. Promoting a collaborative, supportive culture increases opportunities for learners to be exposed to diverse viewpoints and values, and these values were extended to when students work at home (Mahendra et al., 2005). All Myimaths homework tasks were marked with a percentage score within the tools database system. Students were told how questions were created, what feedback, assistance or help features were available, and how they could re-attempt their homework. Also, it was imperative to look at the type of technological considerations the tools may have and what access students had to their marks on completed tasks.

Students could complete the task as many times as they wanted to achieve their best mark, but as mentioned earlier, only the most recent mark is stored in the WBH application's database. A record of how many times the student had completed the same task is kept by the WBH tool. Students, teachers and other interested parties who have access to personal login details can access the database at will and monitor achievement records. For this study, students were initially asked to complete the task a maximum of two times for both the pre- and post-tests. However, this rule was often not adhered to. It was acknowledged from the initial pilot study that this ability to re-take tests could have a devastating effect on the overall results if all participants wanted to score 100% and somehow worked collaboratively together to achieve that. Therefore, students in this study were asked to behave in their usual manner when taking the homework task, and they were reminded that honesty was an integral part of the success of the study. This was done to try to prevent design contamination of multiple homework submissions, thereby increasing the favour of WBH over PBH. The tension described here can be aligned with the desirable ways in which students' work; whether it is through collaboration, resilient determination or the will to succeed that is associated with achieving the maximum score possible (Sartawi et al., 2012). Sartawi et al. (2012) describe a process called introjected regulation, where a student's behaviour comes under pressure from others. Introjected regulation has the effect of making the student behave well in order for others to respect them, and this they believe helps them to avoid inappropriate behaviour and shame. The pilot studies demonstrated that students would not exhaust any facility of multiple submissions with PBH even if they could. No guarantee could be given that students would still not work together to pursue the highest marks. However, this possibility was addressed in the review of the homework results, interviews and the study's limitations in Chapter five.

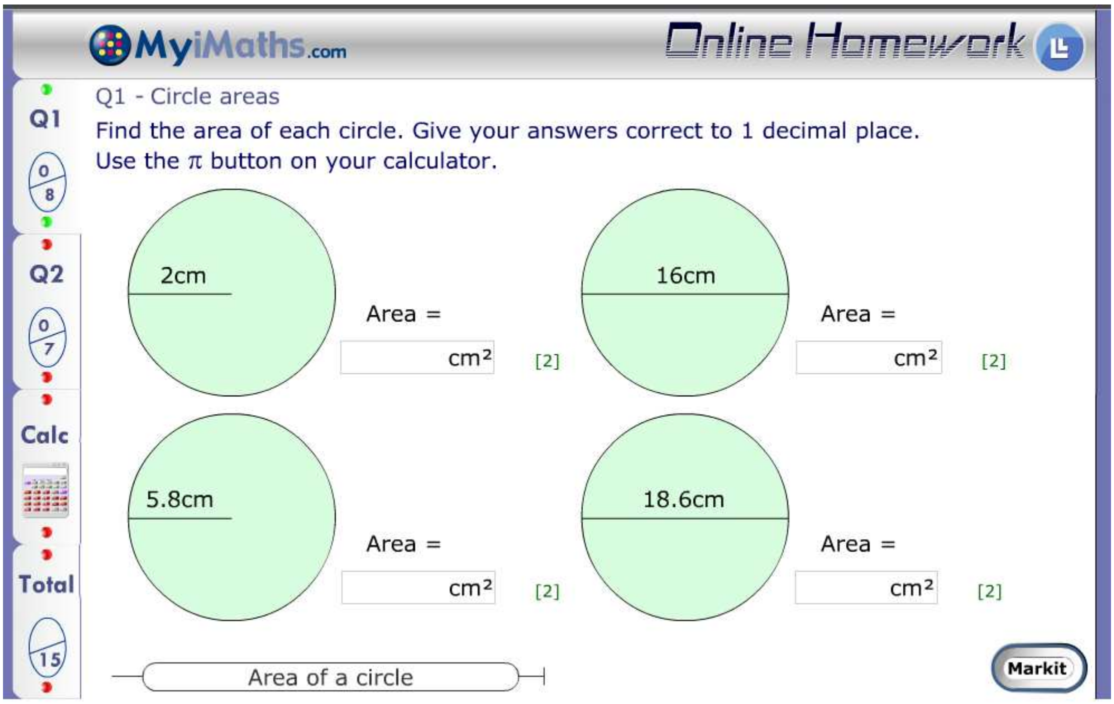


Figure 4. Myimaths grade 7 Example question used.

Figure 4 depicts the first question in the year seven homework task using Myimaths. Students were required to find the area of each circle to one decimal place using either their calculator or the one provided by the tool. In the exercise, students needed to have the prerequisite knowledge of the radius is equal to half the diameter, and the diameter is double the radius. Therefore, Q1 reinforces procedure by getting students to input numbers into the formula $Area = \pi r^2$.

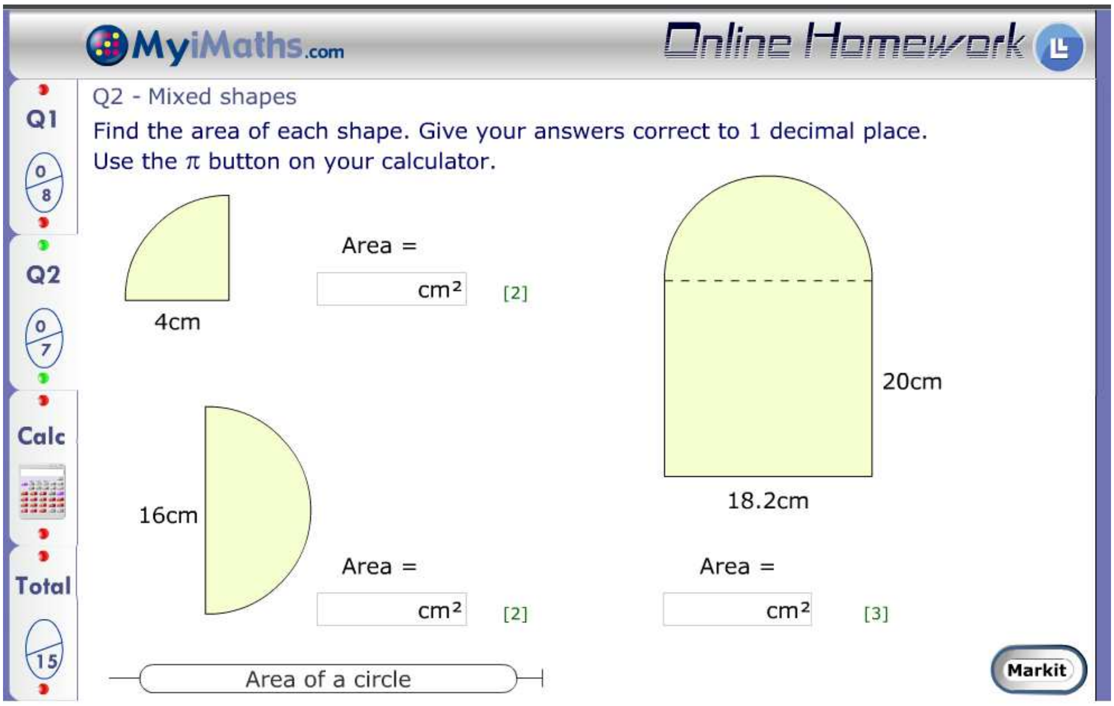


Figure 5. Myimaths year seven, question 2.

Question two of the year seven homework task (Figure 5) required an understanding of compound and fractional circular shapes. This type of illustration is indicative of the structure used to evaluate student learning using Myimaths across topics and year groups (Watershed, 2011). Teachers considered this WBH task to be accessible and supportive in both the boys' and girls' schools as it had limited use of additional language that could hinder the progress of students.

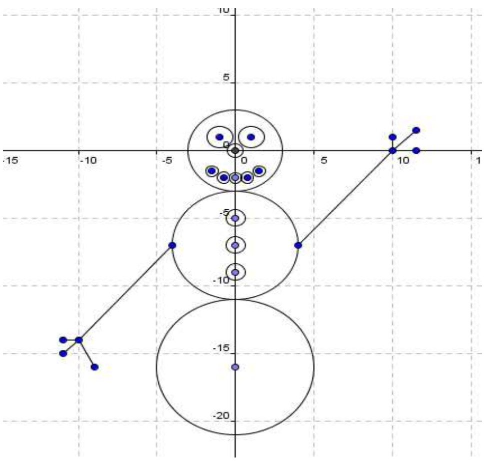
3.6.4 GeoGebra

The second WBH delivery method used was that of GeoGebra. Students could access homework via a teacher set Classtell.com website. GeoGebra allows students, irrespective of their mathematical ability, to investigate and explore key mathematical ideas through the creation of figures and shapes. GeoGebra's multiple representations of algebra, geometry-to-spreadsheet programmes allows the teacher and student to find and define possible relationships between objects (Briscoe, 2012; Holan, 2014). Also, I chose GeoGebra because

it fitted the ambitions of the ADEC to provide a constructivist approach to teaching and learning. GeoGebra is different from Myimaths, as Myimaths is considered to be an Online textbook that facilitates a more "direct instruction" approach to teaching and learning (Watershed, 2011, p.3). Besides, the cost of acquiring new technology is somewhat of a determining factor to enhance student interaction and motivation, and GeoGebra offers this without cost concerns.

Initially, to make students familiar with the tool's applications, I used a worksheet conducted for an experiment for my MSc at Warwick University. The worksheet "The Equation of a Snowman", was used to help students become familiar with the tool features of GeoGebra while allowing them to understand and recognise the equation of a circle. Before this study, I had taught some year 11 lessons designed to reinforce student knowledge by practicing equations of circles using GeoGebra as a learning tool. Students were required to understand how to use the basic functions of GeoGebra, such as plotting equations and points and understand the standard form for the equation of a circle $(x-h)^2+(y-k)^2=r^2$. As part of the task, students were required to manipulate circles by changing the values of h, k and r. Also, students needed to find the centre and radius of a circle when the equation is in its standard form.

Figure 6. The Equation of a Snowman



Students received only one 45-minute lesson in the computer room before this exercise. In this lesson, they could explore the software and discover items in the menu bar before receiving the homework. Students also were introduced to constructing simple shapes and getting the shapes to move around. They did this by using some of the drop-down features from the menu. The aim was for students to complete their snowman over two 45-minute lessons and address questions on circle transformations at the end. The instructional itinerary was a quick review of the equation of a circle. I explained to them that part of the lesson was for them to explain what the values *h*, *k* and *r* represent, as well as what happens when one changes the values of these variables and how they might alter the circle. I had a computer connected to an interactive whiteboard and a prepared worksheet with a step-by-step guide on how to complete the snowman (see Appendix 4). I started the task of completing the first two steps, and then I allowed the class to interact with the technology and their peers. I facilitated the process by moving around the class, addressing any problems, questions or concerns. Once students had completed their snowman, the task was "wrapped up" with students completing certain statements for homework using a GeoGebra applet.

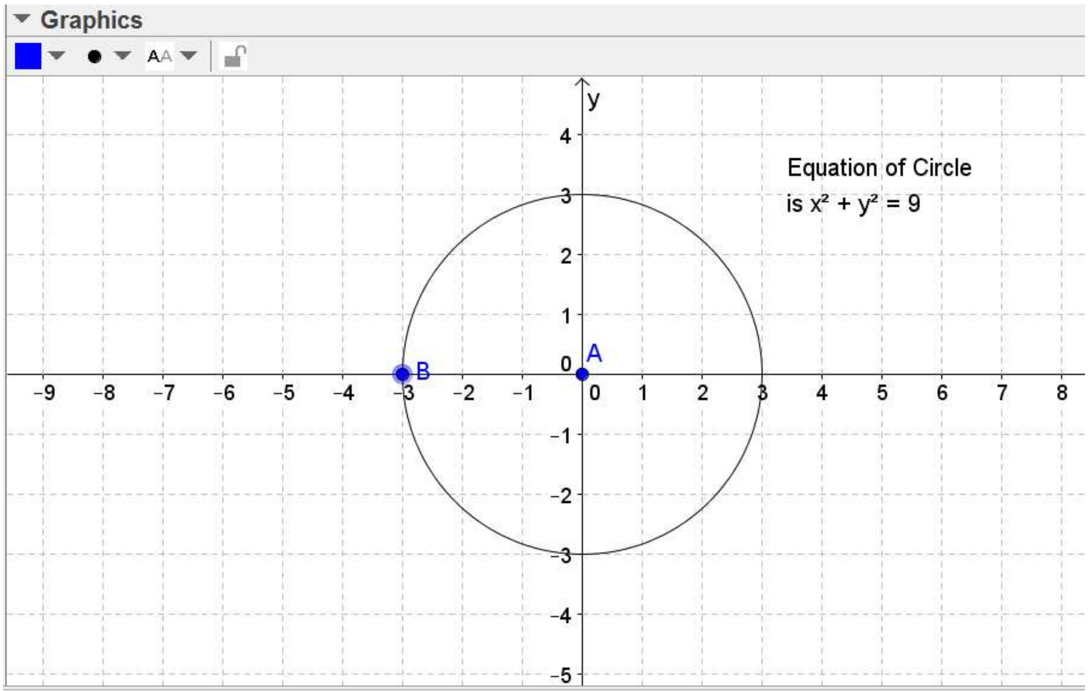


Figure 7. Equation of a circle with centre at the origin.

Figure 7 was given to students to access via the Classtell.com website. The circle was created with a movable centre at *A*, and a moveable point at radius *B*. Points *A* and *B* could be moved in any direction on the grid to see how the equation of the circle would transform. The algebra view window would help students to identify with what transformation took place and how it would affect the variables h, k and r^2.

In Figure 8, points *A* and *B* are moved away from the origin and −3, respectively, and students could see the transformation that took place with the circle equation. This and other examples were used to help them answer the homework statements.

The following were the GeoGebra homework statements students had to complete:

- The general equation of a circle is____

- Assuming we have the unit, circle centred at the origin $(x^2 + y^2 = 1)$, then if it is shifted 4 units to the right the equation becomes____

- If it is shifted 3 units down, it becomes____

- If its radius is increased by 6 the equation becomes____

- Finally, students were asked, If the circle is shifted 2 units up and 7 units left, and its radius is increased by 3, what is the equation?

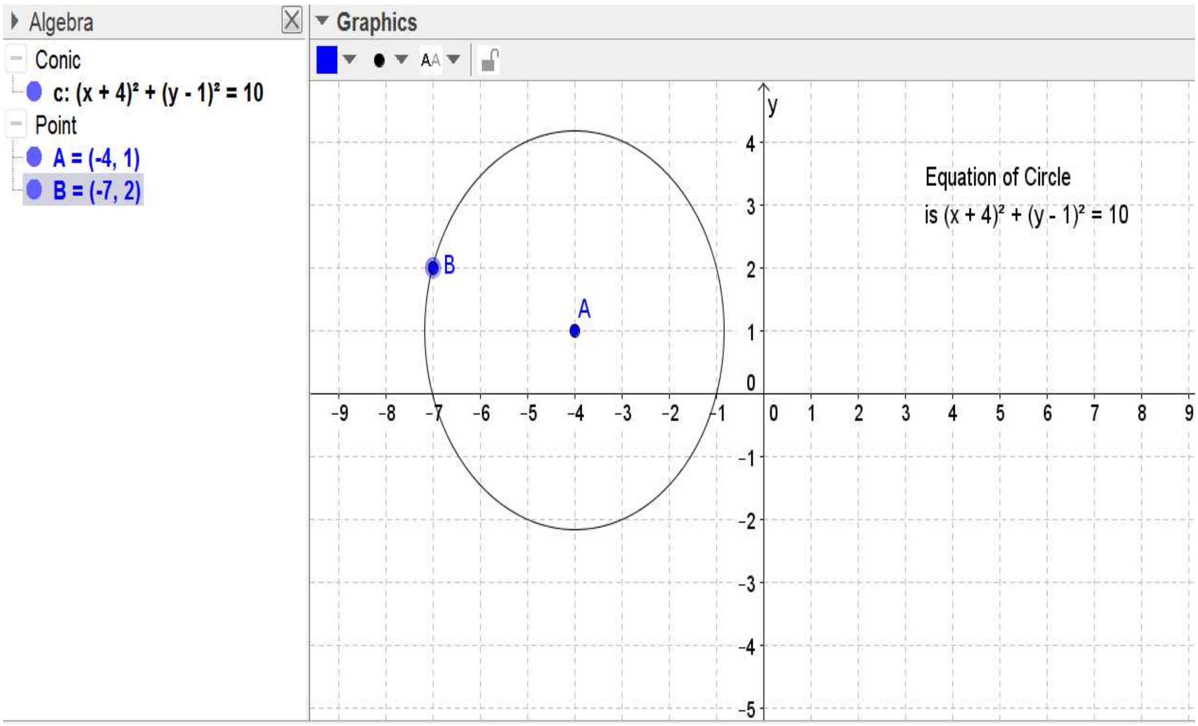


Figure 8. Circle equation with Points A and B moved away from the origin.

The intervention (WBH) group was given preparatory classes in their respective schools for about a week and then assigned a homework task. The control group was given their homework task using the traditional method of PBH, which excluded the use of GeoGebra. Preparatory classes with the use of GeoGebra was given to all students to get them to be familiar with the tool features and to support them if they were selected to be in the WBH group. Table 1 shows that the participants were year 10 and year 11 students who were randomly selected from the four schools. Table 1 also shows that there were 104 students involved with GeoGebra (WBH) and PBH tasks, 49 from year 10 and 55 from year 11.

Table 1. GeoGebra and Paper-Based Homework Participants

		Frequency	%
Valid	year 10	49	47.1
	year 11	55	52.9
	Total	104	100

Table 2 divides student participants by school. This breakdown shows that there were more boys involved with the GeoGebra homework tasks than girls. This situation occurred due to difficulty accessing the girls' school in order to gain access to the female teachers and girl students (a culturally sensitive issue in the UAE). However, 30 girls from the two selected girls' schools out of the 104 students randomly selected managed to complete homework tasks. Three of the four mathematics strands (algebra, shape, measurement and data) were covered (see Appendix 2 for GeoGebra WBH and PBH tasks).

Table 2. Breakdown of participants from selected schools

		Frequency	%
Valid	Boys School A	41	39.4
	Boys School B	33	31.7
	Girls School A	16	15.4
	Girls School B	14	13.5
	Total	104	100

Table 3 presents the number of students assigned to each mathematics homework task by strand. The boys were assigned homework for the three strands, but the girls were only assigned homework on measurement and data. Seventy-four male students were selected from the boys' schools and 30 from the girls. Students had their usual class teacher to provide them with their GeoGebra training, as well as providing additional help and support with their assigned WBH and PBH task.

Table 3. Breakdown of GeoGebra Homework Tasks Completed by Strand

		Frequency	%
Valid	Algebra	32	30.8
	Shape	17	16.3
	Measurement & data	55	52.9
	Total	104	100

The WBH tasks were marked out of 25 in four categories. Table 4 uses an example from Boys school A where seven students were participants in the WBH group for the pre- and the post-test. The table shows how the four categories were used by the teacher from the adapted rubric to evaluate the students' WBH. The use of tools, the correctness of construction, presentation style and the teacher's discretionary mark were used based on how much help each student received from their teacher in order to complete the task. Once the student self-assessed the correctness of their construction, they would upload their completed response for their teacher to evaluate. Upon evaluation of the answer given, the student can then (if incorrect) continue to solve or review process errors and then resubmit. The more help received, the lower the score. The student's final mark was the sum of the four categories, as is seen in Tables 4 and 5 below (pre-test and post-test final score). It is important to note that the same students were involved in the pre-test and the post-test. Missing cases in the post-test WBH could have been due to several reasons, but one strong reason could have been the award of a high mark attained in the pre-test, which made the students less motivated to be involved in the homework process again. Another reason could have been student concerns as to where they were with the curriculum content and their upcoming assessments. It was explained to students that the homework content would help and support them with their assessments, but they may have perceived otherwise. Some students who achieved a high mark in their pre-test PBH did express a lack of motivation to do the post-test. Looking at cases in tables 4 and 5, we can see that there were three scores above 90% in the pre-test and two students who achieved scores of 97% and 99% did not do the post-test. The asterisk indicates this beside the result in table 4. The number of students that were involved in the GeoGebra WBH and traditional PBH tasks (investigating trigonometric functions) can be seen at the end of Appendix 2. Tables four and five are an illustration of how the GeoGebra WBH scores were accumulated.

Table 4. Breakdown of the GeoGebra Homework Final Mark Pre-Test.

Year	School	Task	Group (WBH)	Use of tools	Correctness of construction	Presentation	Teacher's discretionary mark	Final mark pre-test
10	Boys A	Investigating Trig functions	1	25	25	25	22	97
10	Boys A	Investigating Trig functions	1	10	10	10	10	40
10	Boys A	Investigating Trig functions	1	15	10	15	12	52
10	Boys A	Investigating Trig functions	1	25	25	20	20	90
10	Boys A	Investigating Trig functions	1	25	25	25	24	99
10	Boys A	Investigating Trig functions	1	15	10	15	12	52
10	Boys A	Investigating Trig functions	1	20	20	20	20	80
Average				19.29	17.86	18.57	17.14	72.86

Table 5. Breakdown of the GeoGebra Homework Final Mark Post-test

Year	School	Task	Groups	Use of tools	Correctness of construction	Presentation	Teacher's discretionary mark	Final mark post-test
10	Boys A	Investigating Trig functions	1	25	25	25	22	97*
10	Boys A	Investigating Trig functions	1	25	25	25	22	97
10	Boys A	Investigating Trig functions	1	25	25	25	22	97
10	Boys A	Investigating Trig functions	1	25	25	20	20	90
10	Boys A	Investigating Trig functions	1	25	25	25	24	99*
10	Boys A	Investigating Trig functions	1	20	20	20	20	80
10	Boys A	Investigating Trig functions	1	25	25	25	23	98
Average				24.29	24.29	23.57	21.86	94

Note. * indicates missing results (did not complete the post-test).

3.6.5 Timing and Delivery of Web-based Homework and Paper-based Homework Tasks

The timings of the WBH and PBH pre-tests and post-tests were negotiated with the class teachers in the four schools. The negotiation was to make sure that all schools were at a similar point in covering the curriculum content and that the homework tasks could be completed on the same timeline (see Appendix 2). The teaching and learning aim was to support the curriculum material taught in class, track and target student progress and reinforce learning. This ethical consideration was a professional decision that aimed to support the teaching and learning process and to facilitate my research objective to answer the research questions. Students were given workbooks at the start of the 2014–2015 academic year, which allowed the teacher to set specific exercises for completion at home. Teachers could set even-or odd-number problems, as well as a whole exercise, to encourage out-of-school learning and build self-efficacy. The control group received their homework predominantly from the *Signpost* textbook and the new *Mathematics for Life* textbooks in years 7–10, given to them by the ADEC. However, on occasion, they were given their homework via a worksheet. Worksheets were necessary with the GeoGebra activities as they had to be created or manipulated to support the learning process within the given timeframe of the lesson.

Moreover, the year 11 students in the 2013–2014 academic year did not have a textbook, so, it was necessary to give PBH tasks via a worksheet or handout. In the 2014–2015 academic year, year 11 students did have a textbook to work with, and on occasion, homework was set from the book. Students answered questions that would assess the same knowledge base on the pre-and post-test. This approach tried to make the PBH tasks as authentic as possible, in the sense that the tasks given for homework were similar to the material the class teacher would use to assess student learning and understanding of the material content taught in class. All homework tasks were given on the same date for the control and intervention groups in the four schools, and students had three days to complete the task, so teachers could give feedback on tasks within the school week before the post-tests took place. The post-tests were in most cases, one week after the pre-test for both the control and intervention groups.

The intervention group used Myimaths for the majority of the WBH tasks due to application accessibility and ease. Appendix 2 shows the homework set for both PBH and WBH tasks. In total, 13 Myimaths WBH tasks were completed, along with four GeoGebra WBH tasks. With GeoGebra, students uploaded their completed work to the Classtell.com website created for them to use. Appendix 2 also shows the GeoGebra activities used for the year 10 and 11 students, the given dates for these tasks and the number of completed activities pre-and post-test for both the WBH and PBH groups.

3.6.6 Comparative Homework Problems

An essential stage of this WBH versus PBH study was to address the issue of similarity between the WBH and the PBH task. The PBH task, referred to as being traditional, was regular homework that the class teacher would give to support the teaching and learning process. The PBH was checked for content similarity, and the time it took to complete the task. The WBH problems were very similar to that of the PBH problems in terms of the required mathematical procedural steps and conceptuality. For example, in factorising quadratic equations, a year nine homework task was given to the control and intervention groups in the four selected schools (See Appendix 7).

A randomly chosen example from the student textbook given as a PBH would be as follows:

Solve: $x^2 + 7x + 10 = 0$,

and the corresponding WBH question would be:

Solve: $x^2 + 13x + 36 = 0$.

Both questions asked students to solve the quadratic equations without the use of a calculator as they are both factorisable. Since the questions were somewhat in line with each other, this allowed students to use the textbook or their lesson notes as a resource to solve homework problems in both the PBH and WBH groups. Even though a support "Lesson" feature appeared in the Myimaths tool to help students practice similar problems scrambled algorithmically, it was not always widely used or understood, and some students did refer to their textbooks and class lesson notes. In the GeoGebra WBH, students could use their lesson notes, textbooks and their peers to a far greater extent to check their solutions, as the feedback was not immediately available Online. The fundamental difference between WBH and PBH delivery is the availability of additional practice questions and the speed of feedback. With both Myimaths and GeoGebra, additional support questions were available to students, firstly, within the tool itself through algorithmic scrambling and, secondly, through teacher interaction via Classtell.com. Several problems could be generated of a similar type in terms of the level of difficulty and conceptual understanding. This helped the students to practice their procedures to develop proficiency for as long as they wanted. Even though it was not a requirement as part of this study, once a certain level of proficiency was achieved, the student could move on to solve questions of a higher order, such as:

$$Solve: 4x^2 - 33x + 37 = -6x + 2.$$

Looking back at the "Lesson" feature would generate as many problems for the student as they desired until they were satisfied with their progress, understanding and development. However, in the "Online Homework" feature, they could enter only the values of x, and it would be marked with a tick, or the correct answer would be displayed.

3.6.7 Feedback Given

As mentioned in chapter 2, feedback plays a crucial role in the theories of teaching and learning. As a reminder, from the constructivist perspective, effective feedback given at the task, the process, and self-regulatory levels are all interrelated (Hattie & Timperley, 2007). It is essential to focus on the constructivist perspective as this is the aim in the ADEC 2030 vision of teaching and learning pedagogy (ADEC, 2012). Hattie & Timperley (2007) also concluded that feedback is more powerful when it addresses possible misconceptions or misunderstandings. They felt that this would help build students' understanding of strategies and techniques that they could use to solve problems. Kulhavy (1977) found that for feedback to be beneficial to learning, the correct answer must not be easily attained. It is believed that students would copy the answer and would not look to devise suitable strategies to try to solve the problem. Therefore, this would not lead to the promotion of learning (Kulhavy, 1977). A three-way matrix looked at the role feedback played in this study by portraying the type of feedback that is given by WBH, including GeoGebra and PBH. Table 6 shows how that feedback is given to the students for the subscription site Myimaths and the free open software tool GeoGebra. All WBH tasks were marked with a tick (✔) or a cross (✗) for the correct and incorrect answers. Students received instant feedback on their WBH tasks with a percentage score that helped them to move on. For the GeoGebra WBH, the evaluation was given via a percentage score, but then later transformed into E, D and M (emerging, developing, mastery). Feedback for PBH was also given via a percentage score with teacher comments and within a timeframe of three to five days.

Table 6. Homework Delivery methods and Type of Feedback Given

Homework	Delivery Method	Feedback	Associated Learning Theory
Web-based homework (WBH) Myimaths	Web 2.0 subscription	*Marked instantly *Giving answer strategy (GAS) for right or wrong answer, traffic lighted with a percentage score. *Prompting answer strategy (PAS) for help & lesson note features *Performance feedback	Behaviourism
GeoGebra	Free open source Students upload homework to Classtell.com	*Immediate from the tool *Marked in a timely manner/delayed *Knowledge of correct response (KCR) *Elaborated feedback (EF). *Adaptive feedback and usually given in class, based on teacher and student evaluation of construction and graded right or wrong *Summative and formative	Constructivism
Paper-based homework (PBH)	Traditional book or worksheet	Within 3–5 days. *Ticks and crosses and a mark given as a percentage score *Instructional * Directive	Behaviourism

Once students answered their homework problems, the feedback was given for their efforts. The type of feedback given varied accordingly, dependent on the homework delivery mode, as seen in Table 6. With the WBH, the simplest type of feedback was given, right or wrong, and the correct answer is displayed. This feedback is associated with the Giving Answer Strategy (GAS). The Prompting Answer Strategy (PAS) was used if students were to access the help features and support lesson notes via the tool, to complete the set homework task. Some feedback was given in the form of praise such as, "Great Job" or "Well done." Also, some teachers posted more descriptive feedback for individual students in Myimaths and in Classtell.com for the GeoGebra WBH, so that when students logged in to their accounts, they could see the teacher's more detailed, and constructive feedback. This type of constructive feedback is more descriptive in its content, as it informs the student with procedural and conceptual directions that they could use to help them answer the questions in the homework task. That did change the nature of feedback that is usually associated with Myimaths. However, it does match the desirable features of the ADEC 2030 vision. The vision of a constructivist pedagogical approach to teaching and learning. In the case of GeoGebra, this would be to inform them as to which tool feature or syntax type to use in the input bar to help them move on with their homework task. Common misconceptions or mistakes would be identified before setting homework tasks, and generic feedback instructions installed in the tool's database were used. In Myimaths, this feature is built-in and was adapted to suit teacher needs. In Classtell.com, the teacher responded to individual class members at will to support instructional guidance. For example, teachers in all four schools who gave the quadratic functions year nine PBH identified a common mistake among students with "directed numbers". The WBH tool was then used by teachers in the class to address the common misconceptions and mistakes and to provide students with instructional help to get them to address any errors made in both WBH and PBH groups (See Appendix 7).

The difference between the WBH systems Myimaths and GeoGebra is the type of feedback given by the tool and what constitutes WBH. Feedback is given immediately using Myimaths, as an answer in the form of a numerical value is predominantly required. With GeoGebra, evaluation and feedback on student work are far more complicated due to the constructive nature of the homework task and features of the tool (Ravenscroft *et al.*, 2012). There were differences in the types of questions asked. Myimaths algorithmically scrambles questions based on the textbook-style lessons it has stored in its database. With GeoGebra, the questions were created by the teacher and I, in support. Questions were based on student knowledge and understanding as to how to use the tool features. It was often the case of giving the student the required input information for students to move on and use the construction to answer set questions. Myimaths also had a "help" feature that students could use to answer homework problems. This type of feature is not available in GeoGebra. It offers a "help" feature to assist with construction, but it will not help in answering problems set by the teacher. However, GeoGebra Wiki and YouTube were used by some students to support their homework tasks. The student was required to interact with the tool, its features and input functions to answer the select problems given to the WBH group. Occasionally, students were further required to complete set procedures to find an answer. However, no marks were awarded for procedural steps. If the student answered correctly, full marks were given. Students had the option to seek the help feature if the answer was incorrect or they were stuck, but any answer marked as incorrect, could not be corrected without the student attempting the whole task again. Syntax errors unrelated to procedural misunderstandings can easily arise, and as a result, students often repeated the tasks.

The diagnostic feedback for Myimaths appears in the form of a correct or incorrect result, with the correct answer displayed. This type of feedback is highly criticised in constructivist theory. However, it does conform to the kind of reinforcement recommended by behaviourist theory (Hattie & Timperley, 2007). When a student is unsuccessful at a problem, they can use the lesson facility to practice examples differentiated by difficulty. For example, in year 11, logarithms WBH, the first question may start with "$\log_3 81 = ?$" The student is then required to input a value. The student can practice this level of questioning in the lesson examples until they are confident to move on to problems requiring more procedural understanding such as "$3 \log x - \log 4y = ?$" Again, they can keep answering similar problems with the same level of difficulty with just the numbers changing until they are comfortable to return to the WBH activity. This similar type of problem generation is hugely appealing to students who want to develop mastery. It is also appealing to students who use such limited feedback as an incorrect answer to try to find out where they had gone wrong. This form of practice can help them to develop determination and mathematical resilience in developing the procedural elements required to solve particular problems (Johnston-Wilder and Lee, 2008).

GeoGebra WBH was accessed via Classtell.com, and students could use the GeoGebra Tube features for help and assistance as well as YouTube to construct and use their product to answer the problems given to them. The feedback was slightly delayed as students had to upload their answers to questions and wait for their teacher's response. The questions that students must answer were also available on the Classtell.com website, or they could have it printed off and given to them in school. That gave the homework assignment a somewhat dual process, involving the "free open source software" that was accessed via the Web and the PBH questions that students must address. For example, in grade 11, students were required to investigate a hyperbola (see Figure 9).

.

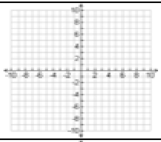
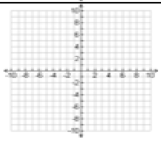
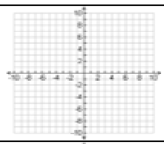
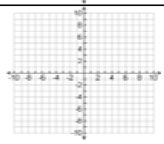
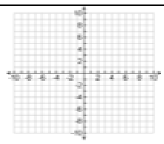
Hyperbola	Graph	An asymptote is where the graph does not exist.
y = 1/x		Asymptotes are at:
y = 4/x		Asymptotes are at: What changed on this graph?
y = - 1/x		Asymptotes are at: What changed on this graph?
$y = \frac{1}{x+1} - 1$		Asymptotes are at: What changed on this graph?
$y = \frac{1}{x-2} + 3$		Asymptotes are at: What changed on this graph?

Figure 9. Reciprocal functions

Figure 9 exemplifies the worksheet that students used to facilitate their interactive experience with GeoGebra at home. They used it to input functions and answered the investigational type question on the worksheet. The feedback from the tool features used to construct functions is immediate, but the student must have the necessary skills to interpret whether the tool features used are correct. The correctness of construction can be confirmed with the use of the algebra display window in GeoGebra. The worksheet that was given combined both WBH and PBH to enhance their mathematical experience. It was an attempt to give students a better understanding of hyperbolas and their transformations through graphical representations and to be able to use this representation to find out where turning points are. For some students, this was much easier than finding the centre of the graph using $(x - x_1)^2 - (y - y_1)^2 = 1$. Students then tried to find the centre, box out the points and join the opposite corners. The students took a standard hyperbola in the form of question 1, in Figure 10, $y = \frac{1}{x} \pm C$, and saw more clearly that, the larger the value of x, the closer $y \to \infty$. Similarly, they saw the larger the value of y, the closer $x \to \infty$. The same was true if students were to look at negative numbers and find that as $x \to -\infty, y \to 0$. Also, when $x \to 0, y \to -\infty$.

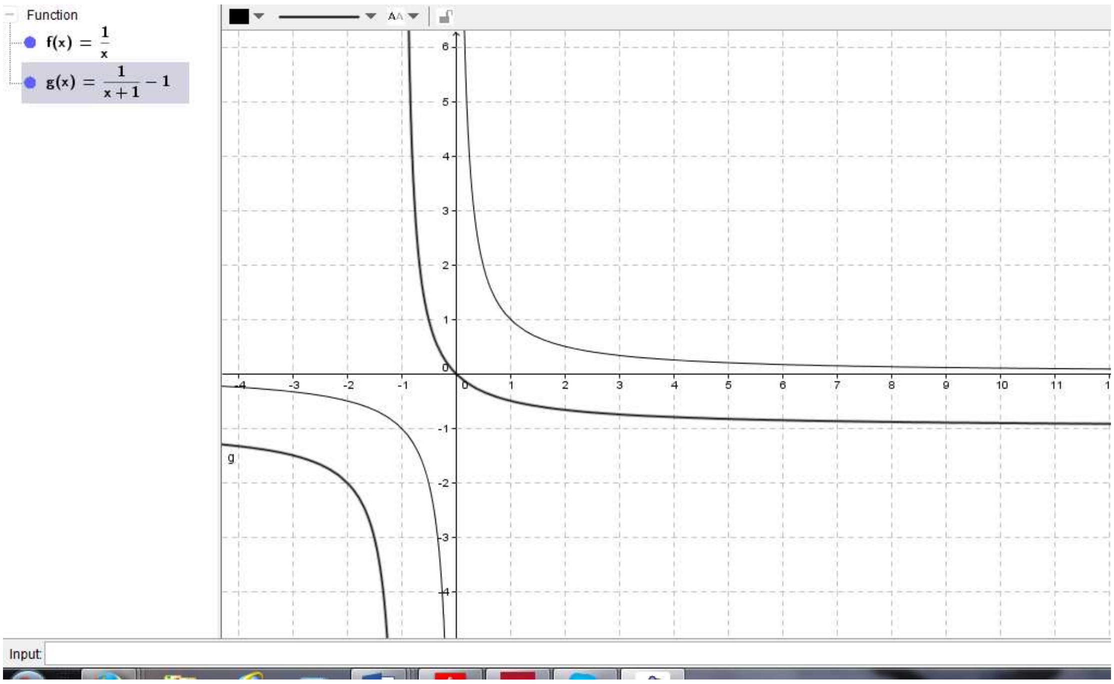


Figure 10. Graphing reciprocal functions

The teacher feedback with GeoGebra was offered to students quickly once the teacher checked for student uploads through the Classtell.com website, but it was not instant. The descriptive feedback was, in most cases, verbal and given in class. The student would then readdress consequent problems at home and, if necessary, resubmit the WBH task. One diligent teacher had student email addresses and was in contact with students who had difficulty or experienced problems. However, it was noted that students often checked their solutions via the Web.

3.6.8 Statistical Package for the Social Sciences (SPSS) for Quantitative Data Analysis

The Statistical Package for the Social sciences (SPSS) was used to perform the statistical tests required and to investigate the RQs quantitively. An alpha coefficient of .05 was used as a confidence level to indicate a 5% chance or less that causal events or effects happened by mere coincidence.

Research Question 1 (Do students interact more with WBH than with PBH?) was restated to test a statistical hypothesis: Do students complete more WBH than PBH?

$$H_0 1: p1 = p2$$

$$H_1 1: p1 \neq p2$$

To find out whether students interacted more with WBH than with PBH, I considered the total amount of homework completion and the number of attempted homework tasks. The rationale was that if students participated in the study completed both pre-test and post-test WBH and PBH tasks without duress; they would have demonstrated one level of homework interaction, which is completion. Admittedly, there are various other levels of homework interaction in terms of quality and engagement that is later discussed, qualitatively using the semi-structured interview data. The first measure of homework interaction considers the number of homework tasks completed from pre-test to post-test. The second measure is the number of homework tasks attempted. For the first research question (RQ), homework attempts are considered because the number of Online submissions was far greater in the early part of the study for WBH tasks than for the PBH. With the PBH tasks, students rarely requested to do more than the voluntary required pre-test, post-test homework. In the PBH control group, this tendency tended to dictate one homework submission for each test.

In the initial pilot study, it was evident that students interacted far greater with the WBH than the PBH due to the availability of multiple submissions. The effect of multiple homework submissions was considered to be a severe limitation in the pilot study. Both the Myimaths and Classtell.com website for the GeoGebra indicated the number of student submissions in the feedback. If all students were in pursuit of and scored maximum marks, it would destroy the study. The total number of WBH tasks completed could be a possible effect indicator, as it is used as a measure of more time spent on WBH activities as a percentage of all homework activities. The idea is that only the completed WBH and PBH activities be considered and not their score or teacher judgement. To determine the level of homework interaction (measured by homework completion), I considered that homework completion was based on the student answering all questions and non-completion was when students had missing answers to questions or had left questions unanswered. The rationale for this was that if a student interacted with the mathematical material content, they would, at the very least, attempt the task but maybe unable to complete the whole task. It could also account for any differences that may occur from pre-test to post-test. The parameters in SPSS were set to register those who completed their homework and those who did not. Any student who attempted all questions of the homework task in either the control (PBH) or intervention (WBH) group assignment received one point for completion and those students who did not attempt all questions received a zero. The percentages of completed and noncompleted homework tasks for both pre-and post-test were calculated per control and intervention group. SPSS computed the percentage of completed homework tasks based on the total number of possible tasks assigned for each group. I then tried to find out if there is a significant relationship between the intervention (WBH) group and homework completion.

A Chi-square statistic was used to evaluate tests of independence when using a crosstabulation. The crosstabulation shows the distributions of the two categorical variables simultaneously, with the intersections of the categories of the variables appearing in the table. The test of independence assesses whether an association exists between the two variables by comparing the rates of homework completion and non-completion for both pre-and post-test. The Chi-square statistic used in the test of independence is labelled the Pearson Chi-square and is examined by merely checking the p-value provided by SPSS. The value labelled "Asymp. Sig," (which is the p-value of the Chi-square statistic) should be less than an alpha level of .05, which is associated with a 95% confidence level (Hartas, 2010). If this is the case, then the variables are not independent of each other and that there is a statistically significant relationship between WBH and homework completion. However, the Chi-square test only informs us as to whether we can reject the null hypothesis of no association; it does not inform us of the strength or magnitude of any association. If any association is found between the variables, then a measure of the effect size may need to be provided.

3.6.9 Student Survey

The student survey was designed and initially piloted in the fall of 2013, and it aimed to gain insight into how students perceived WBH. It was given out in the third and fourth week of October 2013 and the second and third week of May 2015 (see Appendix 16). The survey was translated from English to Arabic for ease of understanding (see Appendix 17). In the main study survey (May 2015) the term "Web-based homework" was replaced with "Online homework" because that was what the students' saw on the screen of the Myimaths WBH tool. A hard copy of the survey was given to students for convenience, as access to the Internet was severely limited in some Abu Dhabi schools due to bandwidth problems. The survey was designed to be anonymous, and there were 25 main question items. The survey was given out at the start of a lesson, and it took approximately 20 minutes to complete. Two-hundred and four students took part in the survey: 124 boys and 80 girls. The students in the survey were from the two boys' schools and two girls' schools selected for the study. They were a mix of students from all year groups (see section 3.5). I chose to give the student survey out on paper to classes for practical reasons. The class teachers offered support and assistance when necessary to help facilitate the completion of the survey in the given timeframe. Support and assistance provided was to the best of the teachers' ability without hindrance and possible undue influence. This could not be said if I were to rely on booking a computer suite for the completion of the task for selected groups at the school due to possible clashes with other classes.

The 25 statement-items on the survey tried to measure three constructs. The constructs are the students' perceptions about their experiences with WBH and PBH. These survey constructs are linked to the RQs, and they try to capture student beliefs and perceptions about these questions. The questions were as follows:

1. What are the interaction effects of WBH compared to PBH on students?
2. What are student perceptions of their learning with WBH and PBH?

Survey results were entered into the software Statistical Package for the Social Sciences (SPSS) using a Likert-type ordering of preferences with a six-point scale spread. The six response items were a measure of value for the completed survey. Participant scoring options were 1 (*strongly agree*), 2 (*agree*), 3 (*neutral*), 4 (*disagree*), 5 (*strongly disagree*), and 6 (*don't know*).

Initially, from the pilot study of 141 surveyed students, survey statement items E1–E7 tried to determine the students' understanding of WBH and to see whether they understood why it was important as a learning tool. Questions E8–E16 were designed to determine how effective WBH is. Finally, statement items E17–E25 aimed to determine whether the students felt that as a result of WBH, they had improved learning mathematics. After looking at both Cronbach's Alpha coefficients and the Inter Item Correlation Matrix (if item deleted section) that was generated using SPSS it was better suited to have statement items E1 to E5, E9, E17 and E25 at determining the interaction effects of WBH. This was due to reorganising the statement items in such a way to attain the highest alpha coefficient. Using the same method, survey items E6–8, E10–11, E18 and E19 were grouped to look at student perceptions as to how WBH could improve their mathematics performance and finally, E12–15, E21, E24 and E25 to gain an insight into student perceptions about their learning with WBH and PBH. The final group of survey questions aimed to find some insight into the structuring of interview questions to address RQ2. The survey was given out to a sample of students ($n = 204$) in year groups 7 to 11 in the mathematics department of the four schools.

3.6.10 Interview Strategy, Questions and Recording

This study completed four semi-structured interviews conducted with groups of six students from each of the four schools. The questions were pre-prepared for the participants. The interviews lasted from 90 minutes to 180 minutes in length. Twenty-four students (12 boys and 12 girls) were interviewed over two years. These students were randomly selected from different year groups and schools (stratified sample-see section 3.5). This method was chosen because it allowed for class teachers to conduct the interviews in the girls' school where there were issues around cultural sensitivity and restricted access for males. Since it is virtually impossible and impractical to design a survey with statements that can capture all possible perceptions, it was necessary to support the survey data with semi-structured interviews that were given towards the completion of the study (Cohen & Crabtree, 2006).

Due to the possibility that the interview experience might be intimidating for students, the semi-structured interviews were conducted with groups of six students—the methodological approach allowed for the possibility of dialogue. Interviewing the students in groups of six was preferred so that the students were able to feel at ease with their peers. The students could then elaborate on their responses to select questions with some degree of comfort. This feeling of ease might not have been attained if I had chosen one-to-one interviews. Students in this situation can feel intimidated and frightened to say something that they may feel could put them in a difficult situation. Having the researcher as the 'minority', amongst students already familiar with each other, helps us to understand the expressed body language, the emotions and reactions to situations (May, 2012, p.62). Student familiarity and confidence with each other helped for the questions to be adjusted accordingly to allow for in-depth responses when possible. However, this was perhaps not true for those students who felt intimidated by their class teacher, especially in the girl schools, where I had to rely upon a teacher to give me the recording of the interview. In this case, the students were much more careful and perhaps constrained with their responses in comparison to the other students. Due to the semi-structured nature of the interview, the researcher and class teachers could go through set questions that were already prepared in advance (see Appendix 25). This approach was necessary for consistency between the schools.

There are disadvantages to this type of approach, such as interview bias, reliability and possible subjectivity, especially since the researcher and the class teacher were the ones conducting the interviews. It could be perceived as an interview that tries to fit whatever agenda the researcher has and bias in favour of WBH (Hartas, 2010; May, 2012). Therefore, to try to increase the reliability of the research method, interviews were recorded and structured around statements made in the survey to get the students response after their experiences with the homework tasks. This qualitative approach is preferred as it increases accountability with the transcribed data, which helps to reduce bias and possible subjectivity (Hartas, 2010). Semi-structured interviews were also preferred, as they provided an insight into how the students' viewed their experiences with the tools used in their homework setting. This method provided them with the opportunity to construct their perceived "reality" of the world (Horn, 2012, p. 37). The students involved in the research were allowed to conceptualise their experiences through analytical insights that could add further value to this study (Horn, 2012). The flexibility of semi-structured interviews allowed the students to hear and share their voices and opinions based on their experiences in the study. It helped to adjust the questioning given the changing circumstances in the interview, and it provided the basis for both structure and direction (Cohen & Crabtree, 2006; Hartas, 2010). The questions were arranged in a more general way than that found in structured interviews. The aim was to provide the study with both flexibility and latitude so that the possibility of further questioning and student responses could take place. For example, questions began by enquiring what students had open on their platforms or computers when attempting to do their mathematics homework. This topic was part of an icebreaker to discuss possible distractions or enter conversations about the use of social media while they were completing their homework. It addressed the theme of communication and other forms of homework interaction linked to RQ1. It was an opportunity to find out what else or who else they were interacting with at the given time. The initial introduction opened the critical topic of student interaction and communication, which gave rise to follow-up questions later (see Appendix 25).

Three methodological approaches were used for the design and analysis of the student interviews. The first was an inductive approach as I had already made specific observations that produced a somewhat fragmented theory that WBH was a more suitable homework delivery method than that of PBH, given the background and culture of UAE students. This "bottum-up" approach (see Figure 11) would eventually lead me to make tentative theories about the data set that was generated. However, initial steps and procedures would have to be followed first (Moretti *et al.*, 2011). The observations came about from interacting with the students in conversation throughout the study. Also, these observations facilitated getting student thoughts on homework tasks. A pattern emerged that indicated student experiences with the homework tools were positive. The pursuit of higher homework scores through multiple homework submissions was an interesting factor to take into consideration. This behaviour made the students spend more time on their homework activity because of this facility. The additional time spent on the WBH tasks was interpreted to be a positive contribution towards mathematics learning benefits, in terms of interaction and improved homework performance. The inductive approach (see Figure 11) used to create questions in the interview allowed for the generation of themes, concepts and ideas to emerge from student responses to set questions, which then generated the data.

Interview questions considered student perceptions about WBH and PBH from the student survey and their pre-and post-test experiences (see Appendix 25). This approach was chosen to examine whether there were changes in student perceptions and attitudes towards homework delivery methods over time (Wilkins and Ma, 2003; Anderson-Pence, 2015). The interview questions initially used in the pilot study, before the main study took place in the autumn term of 2012, were adapted and improved through inductive reasoning. This inductive reasoning considered the ongoing interactions between students and their teaching staff throughout the study. Therefore, many interview questions were posed. The adapted version accounted for observed patterns of behaviour and interaction with the assigned homework material given to students in the initial pilot study and mid-way through to students in the main study. The experience gained over time throughout the study of student, teacher and researcher interaction allowed for students to respond to the questions in a way they would not feel constrained. Students were able to somewhat freely express their views and opinions in a structured way (Charmaz, 2006; Hartas, 2010). For example, the question "How do you learn maths at home using the WBH tool Myimaths compared to PBH?" was changed to "What are the main differences in the way you learn maths at home using Myimaths compared to PBH?" The interview questions thus took cues from differing circumstances, but the structure of the interviews remained similar throughout. Open-ended questions such as, "The questionnaire indicated that most students re-do or revisit their Online homework, could you explain why?" provided a focus on student behaviour that could help to validate a construct or theory. The generation of themes, concepts and ideas is part of the inductive analysis process where the researcher looks for patterns in the data that can better explain what is happening.

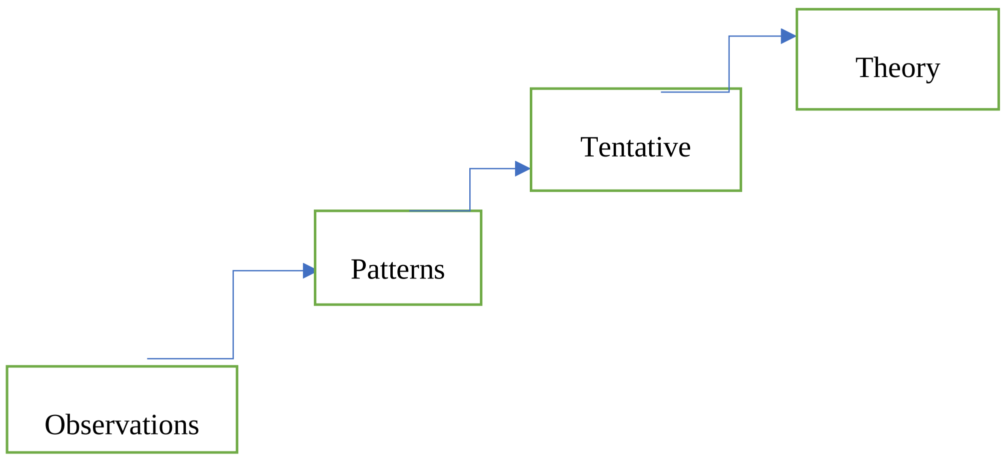


Figure 11. Inductive research approach, "bottum-up."

The primary focus and justification for the student interviews were to account for their real-life experiences and views of their interactions with both homework methods of WBH and PBH. Therefore, an inductive approach was predominantly used in the first instance, to try to gain insight through the eyes and minds of the student participants (Moustakas, 2011). A deductive approach to content analysis followed this in presenting the findings (Cresswell, Ivankova and Stick, 2006). The second approach was the decision to use content analysis, which came after the completion of the study. Content analysis was used to analyse and interpret the transcribed text. Content analysis is a research method that allows the researcher to find and conceptualise social patterns of behaviour or trends in the data set observed (Walsh *et al.*, 2015). The core study of WBH being a more suitable delivery homework method than that of PBH in the context of the UAE is the concept under investigation. This method of interpretation was used to clarify the purpose of the study based on the students' understanding of their experiences with the homework delivery methods, WBH or PBH (Rennie, 2007). Student responses to initial themes were coded using the qualitative software NVivo. The findings consist primarily of the keyword content analysis, coded into themes or categories using memos to analyse the content. This process was completed manually using NVivo by highlighting the searched-for text about the theme and dragging over from the results box to the Nodes box under the relevant category.

Further understanding of the student participants' experiences was gained by adapting the phenomenological research methodology used by Moustakas (1994). Moustakas used a modified version of the Van Kaam (1959) method that involved the understanding, meaning and the structure of a person's or groups of individual experiences (Barbour, 2011). This third methodological approach applied to the analysis enabled me to find patterns, trends and shared beliefs from the lived experiences of the participating students. Thus, the analysis of the transcribed data was an adaptation of Moustakas's (1994), phenomenological approach to get a good "lifeworld" understanding of the student's usage of WBH in comparison to that of PBH (Rennie, 2007; Barbour, 2011; Brooks and Psychologist, 2015, p. 642). Common themes or parent nodes from the lived experiences of the UAE student participants were mapped out and identified. Since the objective of the semi-structured interview questions was to gain a comparative insight into student experiences with WBH and PBH, the RQs were used as a guide to help with this focus and comparative analysis. NVivo was used to reduce the transcribed text that included the elimination of repetitive words and phrases. This process was used to increase the quality of the participants' experiences with the homework delivery methods (Cresswell, Ivankova and Stick, 2006; Rennie, 2007; Moustakas, 2011; Walsh *et al.*, 2015). In each of the grouped cases that comprised coded individuals, a real-life textual account description of the homework experience was given (Corbin and Strauss, 1998). The synthesised description that includes the interview questions, emergent themes, and a coded narration of the student participant responses to their lived experience, is indicative of an integrated account of the three methodological approaches used for the design and analysis of the interview process. The process exemplifies the inductive approach, content analysis and the Van Kaam methodology.

Interviews were recorded using Evernote and uploaded to QSR NVivo. Evernote is a cloud-based notetaking and recording application, which I downloaded onto my smartphone. The smartphone was password protected and suitable for interview recording as it affords anytime and anywhere access (Ifeanyi and Chukwuere, 2018). Evernote is compatible with NVivo, and the notes can be directly imported from the cloud-based platform. Using the NVivo software helped to organise, arrange and filter a vast amount of data. Once coded, the text assigned to the code was easily viewed and arranged so that it could be put into a category that addressed the RQs. Also, NVivo could run specific searches that would find words or synonyms related to a common theme. The transcript was then formatted in Microsoft Word such that it could be successfully uploaded to NVivo. Interview questions were assigned headings and then displayed in the contents section of the tool. This structure simplified getting from one section of the transcript to another. It also helped to put the selected texts into properties when importing the transcript into NVivo—in short, formatting the interview transcript as such, facilitated data analysis. Moreover, it helped to reduce the amount of time required in repeatedly sifting the data manually.

3.6.11 Using NVivo to Verify Codes, Develop and Clarify Categories

The software program NVivo was used to analyse high-frequency keywords related to WBH and PBH. This strategy helped to determine student perceptions based on their real-life experiences with the homework-delivery methods. Addressing frequency word usage was the first step of the analysis process. The second step was to code the comments and responses to the semi-structured interview questions and to organise them into themes and categories. The third step was to decide which categories were the most important and to examine them for irregularities or inconsistencies with the main RQs and the research process itself (semi-structured student interviews). This process would help to resolve any dilemmas with the collected data (student pre-and post-test homework experiences and in the student survey).

With the NVivo tool, open coding was used for the semi-structured student interviews. A process of manual coding did take place in the first instance to identify the interviewed students in their respective schools. The coding process is evident in the interview transcript that was uploaded to NVivo (see Figure 12). However, using open coding in NVivo gave an extensive range of unstructured results.

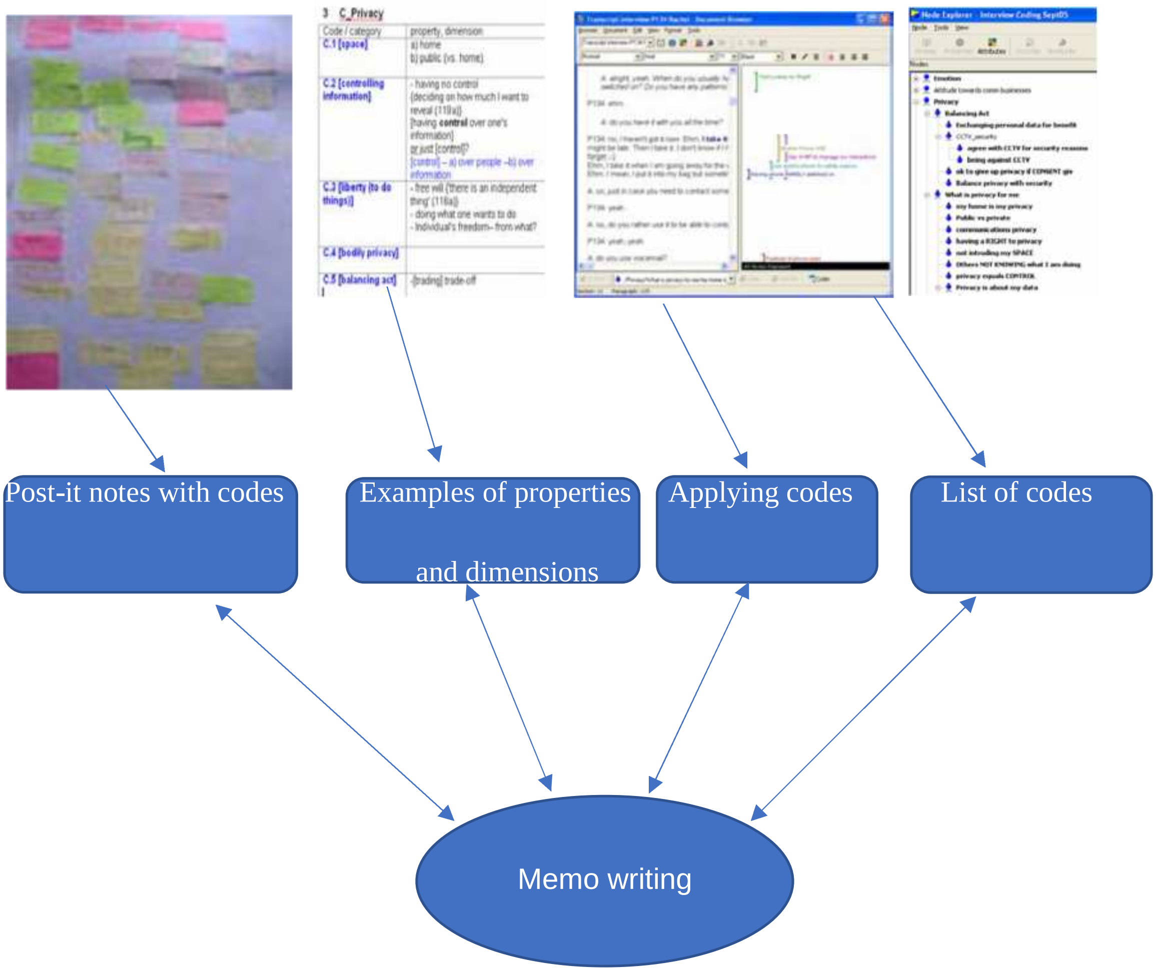


Figure 12. The coding process.

Figure 12 is an example of the coding process used. It started with the post-it notes that led towards memo writing from a more organised and focussed list of codes. Focussed coding tried to structure these results into themes. The objective of focussed coding was to identify recurrent patterns, rethink the general topic and to regroup student responses into categories that could address the RQs (Charmaz, 2006). For example, in Figure 12, the coding for whether the students experienced greater communication with their peers whilst interacting with the tool was commonly expressed through the usage of their phones. Hence, the word "phone" became a sub-theme associated with greater communication. A process of carefully comparing student responses to interview questions was used, as well as the comparison of categories that included both properties and dimensions. For example, I had communication as a theme that had a sub-theme: the phone. This sub-theme captured times when students used the phone as a method of communication with their peers and friends to discuss, find out answers to consequent problems and generally seek help with their homework task. However, this was done using the content analysis methodology guidance on coding. I worked through each of the student responses to questions in the transcript, line-by-line. This method enabled me to get a better understanding of the key themes and abstract categories that could be conceptually related, particularly in the case of student usage of social media and the theme communication. Keyword frequency and aligned phrases were highlighted in the tool from the search function and noted on post-it notes like those shown in figure 12. Memos were written to try to filter through the student responses and arrange them with the created themes that could address the RQs. The more student responses coded, the more the post-it notes started to look like a brain-storming exercise or a map that had branches to specific categories. Memos were written and used throughout this process to help keep pace with thought processes that linked the coding to the categories that could later address the RQs.

Creating codes with reflective memo-writing was a system used throughout the interview procedure and when addressing the final interview transcript with the data from all four schools. Codes were updated continuously to help merge the interviews and to produce one final transcript. Since the schools were not competing against each other and since there was no distinction between them, one final transcript that addressed student responses to the set questions was deemed appropriate (Jehn and Doucet, 1997). A final matrix was put together that held categories, codes, properties and dimensions (see figure 13). Student responses and comments were added to try to align them to the RQs.

Student Quote	Coding	Theme
Once I am on the Internet I'm always interacting with my friends whilst I'm doing my homework.	Reference 1-0.27% coverage Students BA5	Communication
We would phone each other to check on the processes used in order to get the correct answer.	Reference 3-0.76% coverage Students BA3 and BA4	Communication
The instant feedback makes you check your work if there are mistakes and you can resubmit to get a better mark.	Reference 31-0.17% coverage Student GA5	Instant Feedback
The instant feedback surely helped. I used my lesson notes a lot more with the WBH than with the PBH. The online lesson notes help as well and was a good way to revise.	Reference 34-0.48% coverage Student GA1	Instant Feedback
Using the lesson notes to revise our thinking if we are wrong.	Reference 2-0.17% coverage Student GB2	Metacognition
It allows us to change our thinking by looking at problems again.	Reference 27 0.15% coverage Student GA1	Metacognition
The instant feedback makes you check your work if there are mistakes.	Reference 6-0.22% coverage Student BA5	More Engagement
Instant feedback helps you to go back and check your work, especially when there are mistakes.	Reference 49-0.23% coverage Student GA3	More Engagement

Figure 13. Matrix of categories and initial framework thinking.

It was essential to try to verify all assigned codes so that they were consistently applied (Corbin & Strauss, 1998; Miles & Huberman, 1994). The first phase of the coding was completed using pen and paper and then matched into groups or categories that helped to identify patterns or trends in the interview data. Student responses were then grouped under a node in NVivo and comparisons were made between the codes used for the transcript data and the codes used and entered in NVivo (see figure 13). The comparison confirmed that the codes used were similar, for example, communication and engagement. The initial coding from the transcript data was too narrow and mirrored the exact words used by the students' in the interviews. The comparison helped to reveal and clarify whether the new codes were representative of the interview data. Categories were used to capture student-coded responses from the four schools and were put together to address the RQs. The codes that were used and grouped into categories conceptually captured what the students involved in both the WBH and PBH tasks had expressed. These were their reported experiences.

All codes and categories that were given to the interview data were applied consistently (Corbin and Strauss, 1998). The interview transcripts were coded using NVivo by manually highlighting and dragging the relevant text to the parent and child nodes (see Figure 13). The initial codes that were written used post-it notes. The post-it notes were then arranged into categories that helped to identify areas of repetition within the data set. These areas of repetition were derived from consistencies in student responses to set questions. Afterwards, these codes were filtered and entered into a Microsoft Word document, under the heading that had the RQ. Some comments were added to the codes before being transferred back into NVivo.

The codes entered into NVivo were compared with the initial codes that were written on the post-it notes to see whether they could represent the transcribed data. The comparison between the two coded data sets showed that the initial codes were perhaps too broad and not nuanced enough to represent the data set accurately. With additional sub-themes or newly created nodes, it was possible to make the themes narrower to fit the data. Therefore, re-coding the interview data was an essential step in getting the transcribed student data into the appropriate categories or themes. The students' responses to questions were recorded in memos and highlighted under the set themes. The codes that were devised conceptually reflected what was said by the students in the interview.

Memo writing helped to facilitate thought and reflection and the development of the codes and categories. The memos were used when trying to establish links between the data and the setting up of categories that could be used to address the RQs. This process provided the theoretical framework as initial coding was developed into more focussed coding. Also, memo writing helped to take away the pressure of having to fit or determine how some ideas could be located in the context of the overall research findings. Being able to leave the memos for a period helped to sort out ideas and to structure them into categories or to remove them later on.

The next step in the organisation of the interview data was to go through each line of the interview transcript and use focus codes that would help to align the student responses to each RQ. This approach helped to identify the issues considered relevant to the students at the interviews. These phenomena were assigned a conceptual label, which became a code or a concept (Corbin and Strauss, 1998). The codes or concepts sometimes overlapped and shared many similar characteristics, put together into categories to possibly build a theory. This process helped to focus on answering the RQs by using the interview data to develop categories. The focused codes helped to guide and structure the categories (Corbin and Strauss, 1998). The development of categories was a two-part process. The first was the process of iterative coding that used a manual method of working through the text and assigning codes to the students from the different schools. This method also involved working through the student responses to develop themes that could address and answer the RQs. The second process was aimed at developing the codes further by grouping the student responses from each school and aligning them to each RQ.

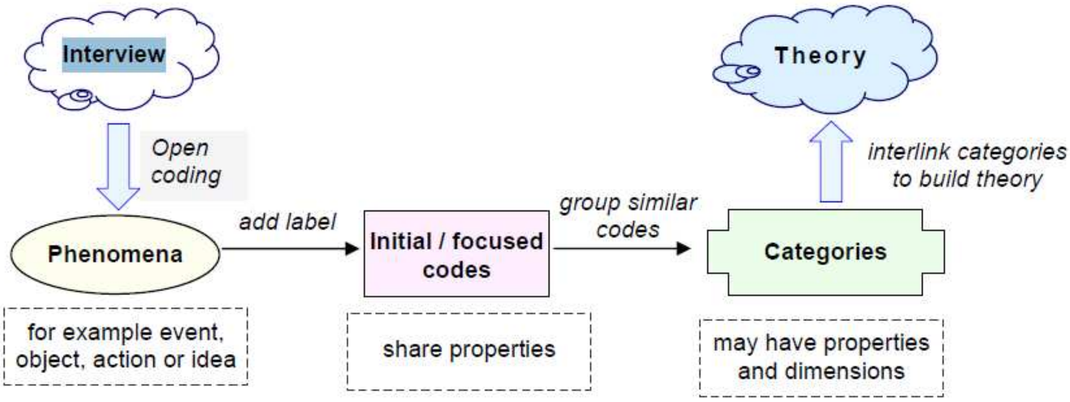


Figure 14. Coding steps in content analysis (Corbin and Strauss, 1998, p. 158).

Using content analysis to count the frequency of words or categories occurring in interview transcripts is vital from the perspective of the interviewees. These words or categories can have essential properties or dimensions. According to Strauss and Corbin (1998), a property can have a general or a specific characteristic of a category. This dimension refers to the location of a property along a continuum (see Figure 14). For example, the category "greater communication" could have the properties of the phone, peers, friends, brother, sister, family members, social media, plus others.

The main category was central and distinctive in the sense that it stood out and tried to define what was happening as part of a developed theory. All of the sub-categories related to the central theme or category repeatedly appeared in the interview transcript (Corbin and Strauss, 1998).

The coding of the data helped to develop the analytical framework when attempting to address the RQs. It is the link between the collection of the data, both quantitative and qualitative that either supported or rejected the study's hypothesis. It also provided further evidence to support or reject a connection between the empirical reality of the study and my initial hypothesis that WBH is a suitable homework delivery method in the UAE. The coding brought together the responses made by the students about their experiences with the WBH and PBH tasks. The coding also helped to explain and predict possible outcomes and scenarios when students engage in similar future activities. Comparing the collected data with others helps to widen the research base and to "ground" what has been found in a possible emerging theory (Charmaz, 2006).

3.7 Qualitative Data Analysis

The qualitative data analysis involved four semi-structured student interviews that helped to capture student experiences with WBH and PBH.

The first stage of the interview data analysis was to identify the units for analysis. It was done by breaking up the interview into useful and manageable chunks of data and becoming more familiar with it. Then, it was necessary to work with individual words and phrases as well as sentences and paragraphs from the transcribed text on a line-by-line basis. The formatting of the text started with student responses in the form of sentences. Sometimes these sentences would be long and contain many facets that would need breaking up on a line-by-line basis. Also, the analysis of the data would require editing and spacing, and this allowed for notes and memos to be made in-between the text. The second stage was to give a comment or code to each line or chunk of data. The code given to the data should try to describe the meaning of the text accurately. Then, the "open coding process" used a particular word to describe the meaning of the text. After open coding, the entire interview, a list of all the codes were made. The initial list was exhaustive and contained similar codes, as well as some redundant codes. It was then essential to reduce this long list of codes to a more manageable and meaningful list, with constant comparisons being made between the new, more manageable list and the original list of codes to see whether or not the new list of codes matched that of the old (Kondracki and Wellman, 2012).

The third stage was to code the codes or to use "closed codes" (Wicks, 2017). This closed coding process tried to identify key themes or categories that would group the open codes. Closed coding was a time-consuming process that involved reducing the coded items, again and again, to get them to address the key themes from the text. The final themes generated aimed to reflect the purpose of the research, and they are exhaustive in the sense that they are sensitive towards the generated interview data. For example, it was essential to investigate whether the themes and sub-themes were distinguishable between the different homework methods. At the end of this stage, a range of themes was put together that reflected the students' real-life experiences of using the tools with regard to the semi-structured interview questions. These themes covered common themes—themes that I expected to emerge out of the data. Then there were the unexpected themes, which I did not expect to find from the data. Some themes were difficult to classify, as they contained ideas that do not necessarily fit into one theme, or they overlapped with several other themes. Finally, there were major and sub-themes. The major themes represent the major ideas and the minor, the secondary ideas from the interview transcripts. The sub-themes that appeared as the "child nodes" are given under major theme headings in Chapter 4.

Stage four was to gather all the interview quotes within a theme and examine as many of the ideas as possible that make up the theme and sub-themes. I then looked at how these themes interact with each other to find out whether there was a sequence or order to which certain textual information belonged. Similarly, I looked for any evidence of any relationship between the overarching or hierarchical themes. This process was essential for some student responses that were initially difficult to classify because they fit into several themes.

In the fifth stage, I repeated the first four stages for the other three remaining interview transcripts. In some, new themes emerged, but the themes largely replicated what was already discovered in the first transcript analysis, as student responses to the set questions were similar. Constant comparisons of the themes were made, and where new themes emerged, they were recorded in memos and coded. At this stage, classification trees (see Figure 15) were built and were essential to moving from specific ideas to general ideas (Braun and Clarke, 2006).

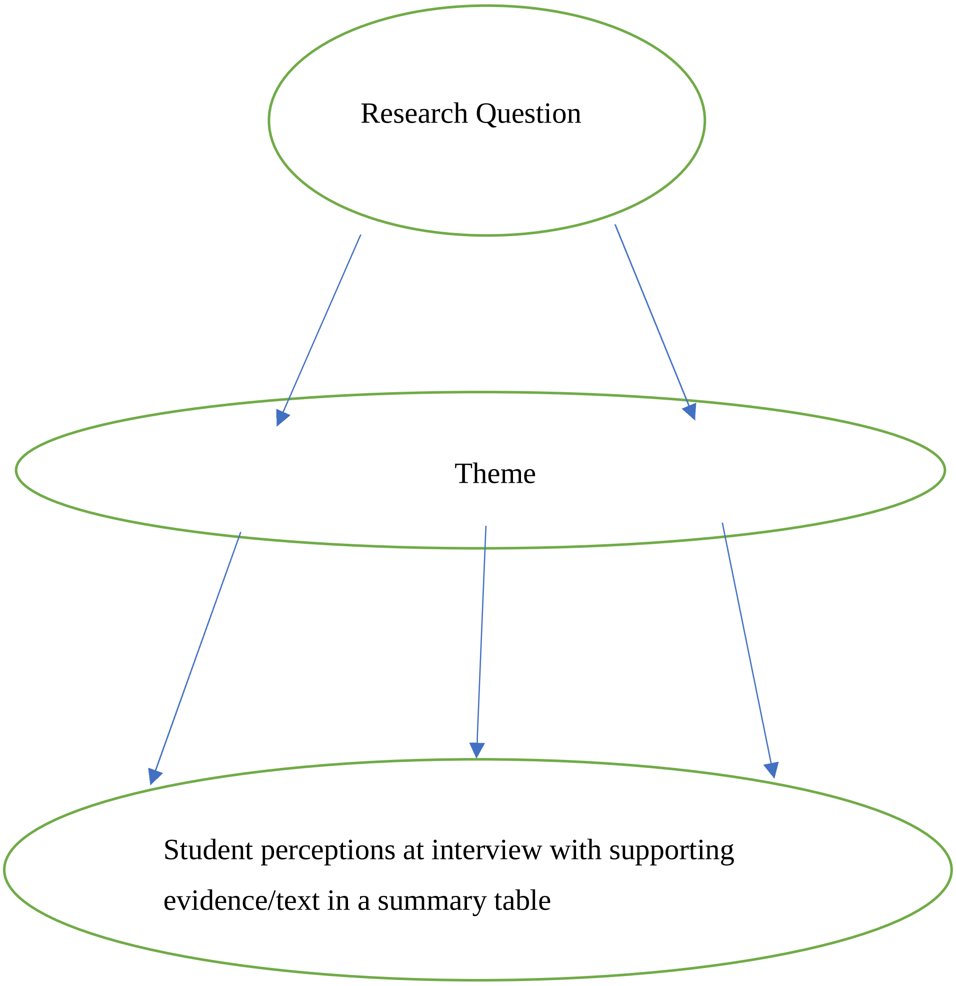


Figure 15. Classification tree for the qualitative data write-up.

The final stage of the qualitative data analysis process was the write-up, depicted in figure 15. After completing all the interviews and reading through the transcribed data, I constructed a narrative of the themes, sub-themes and codes. This narrative describes the themes with quotes from the interviews that are aimed at supporting my ideas. All of this information was organised and led by the RQ. It was then aligned to the theme that was generated or chosen to address the RQ. An interpretation of the meaning of the theme, then followed, with evidence from the transcribed data to support the RQ. This supporting evidence included students' perceptions of their lived experience during the study. Their described experiences were followed up by a discussion of the interrelationships between the sub-themes and the themes. These themes highlighted the theory that I set out to develop. A deductive, thematic approach was used in the very last stage of the analysis process (Braun and Clarke, 2006; Wicks, 2017). This analysis process led to the presentation of the results in three parts. So, the emergent themes were used in a three-step process of analysis as follows:

1. RQ,
2. theme, and
3. student perceptions.

This "top-down" approach was used to inform my interpretation or to provide possible explanations for the hypothesis tests conducted in the quantitative data analysis (Wicks, 2017). This method was chosen to add authenticity to the research process. The observational data from the student interviews, namely the quotations used from the generated themes and sub-themes, were used as evidence to either support or reject my theory (Braun and Clarke, 2006; Moretti *et al.*, 2011; Kondracki and Wellman, 2012). This "thematic analysis" methodological approach can be used in conjunction with content analysis, where the RQ forms the basis of enquiry. After thoroughly examining the transcribed data to develop themes, I used the themes generated by the supported text to answer the RQ (Braun and Clarke, 2006).

The content analysis method used in this study described and classified the written transcribed text into identified categories that had similar meanings to that of the related text (Moretti *et al.*, 2011). The categories that were created represented the views, opinions and experiences of the participating students involved in the PBH and WBH control and intervention groups. The classification of the written text into identified categories of similar meaning was put together with how I thought things should work, through the students' experiences with the tools and through my experience of working with children (Corbin and Strauss, 1998; Walsh *et al.*, 2015).

Substantive coding was used to capture critical levels of conceptual abstraction derived from textual exploration and word usage concerning theoretical underpinning (Corbin and Strauss, 1998; Walsh *et al.*, 2015). For example, when looking at the possible positive interactions between the students and the tools used. This interaction can be two-fold. The first, is the interaction between the student and the use of Myimaths and GeoGebra, and second, would be their positive interaction with other stakeholders, their peers, parents, friends and other interested parties. The analysis aimed at finding keywords associated with the main conceptual theme and then considered the student or students' response that could shed light on their experience and on addressing the RQs. Figures 12 and 13 are examples of items coded to try to address the notion that students communicated far more often using WBH than using PBH, albeit the more frequent communication was not always perceived positively. The students continued to interact with others via social media or mobile communication technology.

In short, NVivo was used to assist in the analysis by creating links, coding and doing simple statistical calculations to find where possible relationships were within the transcribed text. The content analysis method chosen enabled me to identify the keywords, paragraphs or themes from the data that could link to the RQs (Hsieh and Shannon, 2005). The content analysis supported the use of direct quotations to help conclude the experiences of the students who had different homework delivery methods.

3.8 An Integrated Approach to Answering Research Question 3

The second research question (RQ2): What are student perceptions of their learning with WBH and PBH?

In order to answer RQ2, a mixed-methods approach was used. Student survey perceptions were analysed with SPSS, and they were used with the recorded student interviews entered in NVivo for qualitative analysis. The 25 item student survey data was entered into SPSS, and the respondents' frequency distributions, means, standard deviation and correlations between response items were compared across all 25 statement items. The student responses to survey items were then placed in tables and appendices to support the main findings from the survey to be presented in chapter four. The survey construct reliability was then checked using Cronbach's alpha and Principal Component Analysis (PCA) to see if the survey items that were grouped to measure the constructs were suitable. Factor analysis was used to reduce further component variable factors associated with the constructs being measured to a minimum to try to parsimoniously explain the variables that were loaded onto the rotated extracted components. The extracted component factors were then aligned to the construct measures when the data were re-tested using the alpha coefficient (Cronbach's α). The first output from the analysis was the table of the descriptive statistics for all the variables under investigation. This output is the mean, standard deviation and the number of respondents (N) who participated in the survey. The following output from the analysis is the correlation coefficient. A correlation matrix gives the correlation coefficients between a single variable and all the other variables in the investigation. If any variable in the Correlation Matrix had a value of less than 0.5, I would withdraw that item from the analysis and repeat the factor analysis test in SPSS. The next stage is to look at the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This measure determines if the responses given with the sample are adequate. The KMO measure should be close to 0.5 for a satisfactory factor analysis to proceed (Kaiser, 1974). Kaiser (1974) recommended that the minimum acceptable value for KMO is 0.5 (barely acceptable) and that values between 0.7 to 0.8 are acceptable, and values above 0.9 are superb. The total variance is then explained by Eigenvalues that reflects the number of extracted factors whose sum is equal to the number of items which are subject to factor analysis. The Eigenvalue table is divided into three sub-sections, i.e. Initial Eigen Values, Extracted Sums of Squared Loadings and Rotation of Sums of Squared Loadings. For the analysis and the final interpretation, we are only concerned with the Eigenvalues that are greater than one. The next part of the analysis process is to look at the Component Matrix, which tells us the number of items that are loaded onto each component. The higher the absolute value of the loading, the more the factor contributes towards that variable which has yet to be named. Ideally, the final named variable or factor should coincide with the construct I am trying to measure. All loadings less than 0.5 were suppressed (Pituch and Stevens, 2015). Loadings greater than 0.4 were pre-set in SPSS as a good value for minimum loading of a variable or item onto a factor (Bunz, 2010). According to Tabachnick & Fidell (2007), 0.32 is a good value for the minimum loading of a variable onto a factor and accounts for 10% of the shared variance. However, in this study, I used the cut-off point of 0.5, given my sample size was 204 pupils. According to Pituch (2015), there is a relationship between sample size and acceptable factor loadings. For a sample size greater than 100, factor loadings are significant at the 0.01 level when they are larger than 0.512 (Pituch and Stevens, 2015). Finally, the idea of rotation must be contemplated to try to reduce the number of factors on which the variables under investigation have high loadings. Rotation does not change anything, but it tries to make the interpretation of the analysis much easier. This can be achieved by possibly deleting select survey items and by using Oblique rotational methods in SPSS. Even though my initial intention was to use the cut-off point of 0.5, the Oblique rotational method of analysis was investigated out of curiosity because some values in the Component Correlation Matrix laid between 0.32 and 0.5. I chose to do this because it could also address the subjective and somewhat controversial literature that supports factor loading values (Hartas, 2010).

Thematic analysis was important in presenting the data for RQ2 so that any interpretation of that data was consistent with the theoretical framework used. The thematic approach used to answer RQ2, included an interpretation of RQ1 and that was based on the students' lived experiences. Hence, the themes generated are aligned with the RQs. Since this study worked on an experimental framework, claims about the social construction of the research topic cannot be made, but the method of analysis for the interpretation of the data was driven by the RQs (Braun and Clarke, 2006; Wicks, 2017). The themes generated have an interconnectedness about them. Student communication involves the interaction not only with the tool but with what is around the student, including people in the home, mobile devices and Internet resources used to assist them in completing the homework task. The instant feedback given from the tool encourages other forms of communication with peers, other parties, Internet sources, reflection on student notes, books and other forms of help. This feedback could lead to the revision of students' thinking as they re-attempt questions that were marked incorrect. Revised thinking is an influential driver of students spending more time interacting with their WBH task, for multiple reasons. Therefore, student engagement is an interconnected theme if students perceive that they spend more time on their homework when it is WBH as opposed to PBH. The categories and connections made from summary tables are the main results of the interviews and contribute new knowledge about the world from the perspective of the participating students in this study. Notably, this new knowledge from the participating students is represented by their quotations, obtained from the student transcripts, which were aligned with the themes and their meanings in a summary table (Wicks, 2017). The summary tables offer "findings at a glance" (Wicks, 2017, p. 254). Since themes are patterns across data sets that are important to the description of a phenomenon, they can be associated and aligned to the specific RQs (Braun & Clarke, 2006; Hartas, 2010; Miles, Huberman, & Saldana, 2014).

3.9 Ethical Considerations

Consent for research was sought and received from students and parents, who signed the consent form issued by the schools' principals. The consent was completed after the approval of a written request to conduct research at the school was issued by the University of London, Institute of Education (IOE) and the ADEC. The students were informed of the voluntary consent process, as outlined by BERA (2011). Students were told that at any time, they could leave the process if they so wished. They could do this by discussing the matter with their class teacher. A written letter was sent home to the participants' parents to both confirm and acknowledge the voluntary consent involvement in the study (see Appendix 28). In addition, the participants and their parents were informed as to why their involvement was necessary and for what purpose the research would be used.

The letter also highlighted that every effort would be made to ensure the anonymity of the participants chosen in any final research publication outside the context of the school. Confidentiality was maintained throughout the study, as students were informed that they were part of the context of research and that they were not the subjects. Therefore, anonymity was assured outside the context of the chosen participants. Student surveys were anonymous, but they did disclose gender. However, since I was the only one able to access the data, I could assure that the students' identities remained anonymous, so no waiver of rights in writing was needed from their parents. No names were associated with responses for recorded items, and an assurance was given that recorded responses to items would be erased immediately after the research was complete. I ensured that students were not identified as a result of putting their gender on the survey. Students were also allowed to "opt out" of answering questions on gender or any of the 25 statement items if they feared some sort of reprisal. The survey and interview data were anonymous, as the names of individuals and the school were omitted. The pre-and post-test data after the completion of the study were deleted to make the participants further anonymous. The Web-based and PBH data used in this study does not reveal the identity of any student or teacher, as only examples of homework activities and their results were given. All the data were stored in a secure private location outside of the school premises, where only I had access to the information, which was password protected.

Interview access to the girls' schools was complicated due to cultural sensitivity about the presence of men in women-only contexts. Therefore, semi-structured interviews were chosen so that their class teacher could go through questions that were already prepared by (me) the researcher. The success of the interview was reliant upon their class teacher going through and recording responses to questions in an orderly manner. Also, interviews were dependent on the teacher's relationship with the randomly selected students. All teachers in girls' schools are female.

There were ethical issues to consider regarding the selection of participants to the WBH and PBH groups. Where a participant repeatedly selected a number that was later found to be associated with the PBH group, and that participant wanted to change to the WBH group, the class teacher and I tried to facilitate this change for reasons of fairness and equity. Only a small number of students complained about repeated selections to the same homework group. Throughout the study duration, this was combated by an automatic switch in two of the classes to avoid participants being repeatedly chosen for the same group. This happened near the end of the study to keep participants happy, and it was implemented at their request.

I followed the review panel's instruction and guidance notes after my upgrade and told students to limit the number of homework attempts to a maximum of two. Limiting homework submissions proved extremely unpopular and, as the students themselves pointed out, "unrealistic". Students told me that even with two submissions, they would simply click the "Next" button on Myimaths and take the homework task multiple times till they believed they were ready to input their login details and submit. With the GeoGebra homework, they could interact with the task as much as possible until they felt the homework was suitable for submission onto the Classtell.com website. This was primarily due to the homework style and type. For equity considerations to prevail, I had no option but to allow students using Myimaths and GeoGebra to interact with the tools as much as they wanted and to investigate this behaviour as a possible confounding variable in the analysis of the results.

3.10 Summary

The purpose of this research study was to evaluate WBH versus PBH and see which homework method was more suitable, given the context of cycle-two and cycle-three students in the UAE. The RQs target some of the interaction effects of using WBH tools, and finally, what student perceptions were about their learning with both Web and paper-based homework. A goal of this study and others like it is to find out whether students benefit from engaging and interacting with WBH tools that would help them to improve at mathematics through the possible reinforcement of learning. This chapter outlines the methods used in order to answer the RQs. A two-group pre-test, post-test control design was used to find and measure the interaction effect of a different homework delivery method than that of traditional PBH. Student perceptions of these measures were collated and analysed using a survey near the end of the study. The survey was given to students after they had completed pre-and post-test homework tasks that compared student homework scores using the WBH tools Myimaths and GeoGebra with that traditionally given via PBH. The third part of this study was the student interviews; this part sought, whether the student data collected and analysed quantitively could be supported by the analysis of the qualitative data with that of student perceptions about their homework delivery methods. The final stage is to consider the findings from this research study with findings in other research on WBH versus PBH studies using the constructs mentioned in the literature review (see chapter 2 section 2.3.1 to 2.3.8).

Chapter 4 – Results

4.1 Introduction

This chapter presents the quantitative and qualitative data findings of the study. It begins by presenting the results of the participant breakdown by school, year group and curriculum strand and then the underlying assumptions used in the study to conduct the tests in SPSS. The two research questions (RQs) are used in this chapter to analyse the data collected from the students' performance homework scores using the tools Myimaths and GeoGebra (i.e., WBH) versus traditional PBH tasks, a survey and semi-structured interviews. Each RQ and the accompanying hypotheses are then answered and, in turn, either supported or rejected based upon the usage of a variety of statistical techniques. Each RQ has its results presented in this chapter, and then they are discussed in chapter five.

4.2 The Participant Breakdown

Table 7 shows the student participant breakdown of the four selected schools. There were 575 (327+248) participants in the girls' school that accounted for 52.8% of the selected schools' population and 514 (267+247) participants for the boys, accounting for 47.2% of the selected schools' population.

Table 7. Student Participant Breakdown by school

School	Frequency	Per cent
Boys school A	267	24.5
Boys school B	247	22.7
Girls school A	327	30.0
Girls school B	248	22.8
Total	1089	100

Table 8. Homework Task Completion by Year Group

Year Groups	Frequency	Per cent
Year 7	93	8.5
Year 8	256	23.5
Year 9	180	16.5
Year 10	398	36.5
Year 11	162	14.9
Total	1089	100

Table 8 shows the breakdown of the number of homework tasks completed by each year group. This year group distribution is grouped by school years, ranging from year 7 through to year 11. It is clear from the table that students in year 10 completed most of the homework tasks (398 out of a possible 1089) accounting for 36.5% of the tasks set in this study. This was by no means a deliberate result. The homework tasks that were given were based on convenient access, suitability and where students were in relation to curriculum content material covered and their up-coming assessment material

Table 9. Completed Homework by Curriculum Strand

Curriculum Task	Frequency	Per cent
Number	373	34.3
Algebra	191	17.5
Shape	431	39.6
Measurement & Data	94	8.6
Total	1089	100

Table 9 shows a breakdown of the number of completed homework tasks that the participant students were engaged with by curriculum strand. The majority of the homework tasks completed were on shape as 431 homework tasks were completed out of a possible 1089. The research covered the four main strands in the mathematics curriculum: number, algebra, shape, measurement and data. Comparative analysis between the strands is not part of this study, and therefore only possible attributable variables will be discussed when addressing the RQs. These variables would include the tasks that are associated with the curriculum strand, as shown in the WBH and PBH tasks in Appendix 2.

Table 10. Control or Intervention Participant Groups

Control/Intervention	Frequency	Per cent
Intervention	543	49.9
Control	546	50.1
Total	1089	100

Table 10 shows that 546 students were assigned to the control (i.e., PBH) and 543 students to the intervention (i.e., WBH) groups.

4.3 Running Statistical Tests for the Data Assumptions in SPSS

The data generated for the two-group control pre-test, post-test design was collected and entered into SPSS to test the assumptions required to run an independent samples t-test. Three conditions must be met as the preconditions for meaningful use, and we need to test to see whether these assumptions were met. These conditions are as follows:

1. independence (participants between and within the groups of control and intervention were randomly selected from the population, and the sample selected for one group has no bearing on the sample selected for the other groups),
2. normality (scores are normally distributed around the mean of the dependent variable) and
3. homogeneity of variance (groups have equal variances in the population).

Assumption 1

In the methodology chapter, I gave an account of how the data would be collected, the size of the sample and how students were selected to participate in the control and intervention groups (See section 3.5). Therefore, this account supports the first assumption. There are possible confounding variables associated with the notion of independence, primarily when students assigned to opposing study groups can interact with each other and are from the same school class.

Assumption 2

To determine whether the assumption of normality had been met, I ran a Shapiro-Wilk normality test in SPSS.

For a t-test to be carried out, the dependent variable should be approximately normally distributed for each category of the independent variable. However, an independent sample t-test only requires an approximation to normal data distribution because it is quite "robust" to violations of normality due to the Central Limit Theorem (Laerd Statistics, 2015). The theorem states that the distribution of sample means approximates a normal distribution as the sample size gets larger, meaning that the assumption can be violated and still provide valid results. The Shapiro-Wilk test was used to test for the normality assumption (Hartas, 2010).

Table 11. Test of Normality Assumption

		Shapiro-Wilk		
	Control or intervention	Statistic	df	Sig.
Post-test	Intervention	.693	536	.000
	Control	.866	531	.000

Table 11 indicates that the post-test homework scores were, not normally distributed, as assessed by Shapiro-Wilk's test ($p < .05$). The test tells us that the students' homework scores significantly deviate from a normal distribution.

Table 12. Post-test group statistics showing mean, standard deviation and the standard mean error

Group Statistics					
	Control or Intervention	N	Mean	Std. Deviation	Std. Error Mean
Post-test	Intervention	536	95.56	6.707	.290
	Control	531	88.87	11.522	.500

Table 12 shows the values of the control (PBH) and intervention (WBH) group statistics ($M = 95.56, SD = 6.707$) and ($M = 88.87, SD = 11.522$), respectively. The group statistics help us with the analysis of the results for the third assumption, as a t-test is run.

Assumption 3

A Levene's test would determine the homogeneity of variance. If the test is found to be statistically significant, it will endorse the rejection of the null hypothesis that there is an equal variance between the groups. Table 13 shows the statistically significant result of the Levene's test when the t-test is run in SPSS $p < .05$, which indicates that the null hypothesis (equal variances between the groups) must be rejected. The violations of the assumption of normality and homogeneity are also further supported when looking at the Q-Q plots and histograms in Appendices 5 and 6. Appendices 5 and 6 show that many students achieved full scores in both pre-test and post-test homework tasks in the control and intervention groups. This was comparatively at the significant level between the WBH and the PBH groups. One hundred and eighteen students achieved full marks on their WBH task and 95 students on the PBH tasks in the pre-test. In the post-test 346 students, out of a possible 536 students achieved full marks in the WBH group. This result is in contrast to the 171 out of a possible 531 in the PBH group. Both groups had improved on attaining full scores, but the WBH group significantly so. The empirical reality of the study in allowing multiple homework submissions for improved mathematics homework score was an ethical consideration given based on what was allowed and what was done in previous studies. The facilities and features the WBH tools have and how students would naturally behave and interact with the resources given was essential to the success of the study and its design. These interaction effects would have to be considered between the pre-test and the post-test, as it could to be a limitation to the internal validity of the study and its design.

Table 13. Levene's Test for Equality of Variance (Homogeneity)

	F	p-value
Post-test	120.212	.000

The result of the Levene's test in table 13, indicates that the assumption of homogeneity (equal variances between groups) is violated. The group variances are significantly different from each other $p < .001$. The result left me with three possible choices; the first is to proceed with the original data set and rely upon the robustness of the t-test given my sample size. Second, to proceed with a nonparametric equivalent test called the Mann-Whitney U test. Finally, to transform the data so that the assumptions of normality and homogeneity are met. All three approaches were used and investigated in this study. However, in order to use these approaches effectively, it is necessary to comparatively look at the mean scores to enable us to get a measure of the central tendency and what could possibly be considered normal for the groups.

4.4 Research Question 1

Research Question 1 was stated as follows: Do students interact more with WBH than with PBH?

Null Hypothesis 1: Students do not complete more WBH than PBH.

Alternate Hypothesis 1: Students do complete more WBH than PBH.

$$H_0 1: p1 = p2$$

$$H_1 1: p1 \neq p2$$

Table 14. Amount of Web-based and paper-based homework completed (in %)

*Control or intervention * Task Completion Cross tabulation*						
		Task Completion				Total
		Attempted both pre-test and post-test	Completed both pre-test and post-test	Completed pre-test only	Completed Post-test only	
intervention (WBH)	Count	191	112	6	234	543
	% Total	17.5%	10.3%	0.6%	21.5%	49.9%
control (PBH)	Count	366	86	9	85	546
	% Total	33.6%	7.9%	0.8%	7.8%	50.1%
Total	Count	557	198	15	319	1089
	% Total	51.1%	18.2%	1.4%	29.3%	100.0%

Table 14 shows the percentage count of the participants who attempted both pre-test and post-test, completed both pre-test and post-test, completed only pre-test, and completed only post-test in the intervention and control groups. It is evident from the above-mentioned table that the percentage of participants who didn't complete both pre-test and post-test was higher for paper-based homework (control group: 33.6%) as compared for the web-based homework (intervention group: 17.5%). The percentage of participants who completed both pre-test and posttest was higher for web-based homework (intervention group: 10.3%) as compared to paper-based homework (control group: 7.9%). The percentage of participants who completed only pre-test was higher for paper based homework (control group: 0.8%) as compared to web based homework (intervention group: 0.6%) and percentage of participants who completed only post-test was higher for web based homework (intervention group: 21.5%) as compared to paper based homework (control group: 7.8%). Total percentages show that the percentage of participants in WBH group (intervention group) and PBH group was almost equal.

A Chi-square statistic was used to find out whether the categorical variables are associated. The null hypothesis of the Chi-Square test is that no relationship exists on the categorical variables in the population and that they are independent. We have two categorical variables, homework completion and treatment (control PBH) or intervention (WBH).

Table 15. Chi-Square Test

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	128.585[a]	3	.000
Likelihood Ratio	132.321	3	.000
Linear-by-Linear Association	120.110	1	.000
N of Valid Cases	1089		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.48.

Table 15 shows that the association between treatment (i.e. intervention with WBH) and homework completion of the pre-test, post-test is significant with Pearson Chi-Square p-value < .001, Likelihood Ratio p < .001 and Linear by Linear Association is also significant with p < .001. Therefore, we can report that a Chi-square test for association was conducted between the type of homework given (WBH or PBH) and task completion. All expected cell frequencies were greater than five, which is indicative of test suitability. There was a statistically significant association between the type of homework given (WBH) and homework task completion, $\chi 2(1) = 128.585, p < .001$. The Likelihood Ratio suggests that the model used is a good fit to suggest that there is an association between WBH and homework completion. This result is further supported by the statistically significant results of the Linear by Linear Association test, which measures trends for the associations of categorical variables.

However, there is a problem with the Chi-square test for association, as it does not inform us of the magnitude or strength of any association. In order to measure for any association (as mentioned in chapter 3) a symmetric measures test was run.

Table 16. Symmetric Measures Strength of Association Test

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.063	.037
	Cramer's V	.063	.037
N of Valid Cases		1089	

Tables 16 and 17 show that the association between the intervention (WBH) and homework completion of the pre-test and post-test is significant with the Pearson Chi-Square p-value < .001, and the Nominal by Nominal association is evident by Phi (φ) with p < .05. Therefore, we can conclude that there was a moderately strong association between the use of WBH and homework completion, φ = .037, p < .05 (Cohen, 1988).

4.5 Research Question 2

Research Question (RQ) 2 was as follows: What are student perceptions of their learning with WBH and PBH?

4.5.1 Student Survey Results

Table 17. Survey Item Statistics

	Mean	Std. Dev	N
E1. I like to do maths homework on the computer.	1.31	.493	203
E2. Online maths homework motivates me to practice maths.	1.53	.981	203
E3. I like to receive immediate scores on my maths homework.	1.41	.749	203
E4. Immediate scores help me to be aware of my performance.	1.71	1.205	203
E5. I like the help and suggestions facility on my Online maths homework.	1.70	1.148	203
E6. I refer to the Online lesson activities to help me complete my homework.	1.71	1.056	203
E7. Online homework feedback helps me to recognise my mistakes.	1.45	.752	203
E8. Online maths homework gives me more chances to practice mathematical topics.	1.50	.829	203
E9. I enjoy doing maths homework activities Online more than on paper.	1.64	1.123	203
E10. The Online lesson review helps me to review mathematics concepts.	1.51	.864	203
E11. I have less anxiety in taking Online homework than paper-based homework.	1.75	1.143	203
E12. Online maths homework helps me evaluate my own understanding and performance.	1.52	.786	203
E13.I like Online maths homework more than paper-based maths homework.	1.47	.828	203
E14. I feel I can be better at maths as a result of Online maths homework.	1.60	1.055	203
E15. I am more motivated to do my maths homework on the computer than on paper.	1.53	.892	203
E16. I am easily distracted when doing Online maths homework.	3.38	1.835	203
E17. I discuss my Online maths homework with my classmates and others.	1.75	1.161	203
E18. My parents are keener to monitor my progress in maths because of Online homework.	1.69	1.185	203
E19. I get help from my family, friends and others in completing my Online maths homework.	1.67	1.026	203
E20. Paper based homework is just as effective as Online maths homework.	1.76	1.201	203
E21. Online maths homework is better than Paper based maths homework.	1.67	1.110	203
E22. The use of English language for my Online maths homework is not a problem.	1.83	1.309	203
E23. My teacher encourages the use of Online maths homework.	1.56	1.626	203
E24. My maths has improved as a result of Online homework.	1.47	.772	203
E25. I spend more time on my maths homework because I can interact with the maths.	1.61	.986	203

Table 17 shows the descriptive statistics for each item, including mean, standard deviation and sample size. The mean score for each item ranges from 1.31 to 3.38, with the lower mean scores' indicative of strong survey item agreement. The mean score for item E16 ("I am easily distracted when doing Online maths homework") can be classed as an outlier as it falls outside the majority of the data (Rousseeuw and Hubert, 2011). The inter-item correlation matrix in Appendix 31 shows that almost all items are correlated significantly with each other (with p < .05) except for item E16. The high correlation between all items shows high construct validity. However, this needs to be supported by a reliability check using Cronbach's alpha and exploratory factor analysis of the statement item constructs that were grouped to measure student perceptions about their learning with WBH and PBH (Ferketich, 1991).

For survey item E16, 39.7% of students were in agreement and 38.3% in disagreement (see Appendix 32). There could have been a misunderstanding of item E16, as all other student responses to items ranged from a mean score of 1.31 to 1.83. The results indicated a strong favourable agreement within the range of the survey statement items E1 ("I like to do maths homework on the computer") to the item E22 ("The use of English language for my Online maths homework is not a problem"). The sample size was 204 students, but 203 students were recorded in SPSS as there was one missing data item from a student whose survey was incomplete because of a missed response to item E15. There were 328 (6.4%) neutral responses and 79 (1.5%) don't know responses to select survey items, the largest of which was survey item E16 that accounted for 22.1% ($n = 51$) of student responses.

Visual inspection of the frequency tables in SPSS showed that out of the possible 204 students surveyed (124 male and 80 female), all the students said that they had access to or could gain access to a computer to do their Online mathematics homework (see Appendix 32).

The main findings of the survey showed that 188 students agreed or strongly agreed with item E24, "My maths has improved as a result of Online homework" ($M = 1.47, SD = 0.772$); 194 students agreed or strongly agreed with item E3, "I like to receive immediate scores on my maths homework" ($M = 1.41, SD = 0.749$); 185 students agreed or strongly agreed with item E2, "Online maths homework motivates me to practice maths" ($M = 1.53, SD = 0.981$); 193 students agreed or strongly agreed with item E7, "Online homework feedback helps me to recognise my mistakes" ($M = 1.45, SD = 0.752$); 182 students agreed or strongly agreed with item E15, "I am more motivated to do my maths homework on the computer than on paper" ($M = 1.53, SD = 0.892$) and in contrast to that, 80% of the students surveyed ($n = 163$) agreed or strongly agreed with item E20, "Paper-based homework is just as effective as Online maths homework" ($M = 1.76, SD = 1.201$). Follow-up discussions with students indicated that the immediacy of feedback was a key feature of homework preference. Students also emphasised the importance of the teacher-monitoring layout processes in PBH and getting feedback to students in a prompt manner. Some student interactions suggested that a key concern was the lack of monitoring of layout from the WBH tool Myimaths. This concern was consistent with the initial pilot study taken in the fall of 2013 and with previous WBH studies (Demirci, 2010; Nguyen et al., 2006). The 81 students that felt they were easily distracted when doing WBH may be due to interaction with social media applications or other distractions that pertain to their home environment. We have no way of knowing whether these social media applications or perceived household distractions were used to support student learning or if they distracted students and took them off task. Eighty-eight per cent of students ($n = 180$) agreed or strongly agreed with statement item E18, "My parents are keener to monitor my progress in maths because of Online homework" ($M = 1.69, SD = 1.185$). This could suggest a homework culture that is supportive of homework completion and improved mathematics performance. The assumption is that with the improved student homework scores and additional time spent on task via the use of multiple homework submissions, whatever distractions took place did not hinder student perceptions about their homework experience, completion and performance.

As mentioned in chapter 3 (section 3.6.9), after looking at both Cronbach's Alpha coefficients and the Inter Item Correlation Matrix, it was better suited to have survey items (E1 to E25 from Appendix 16) organised and structured in a suitable way to answer the research question. The restructuring of items would help to gain a better insight into student perceptions about Web-based and PBH. From the constructs used in chapter two (section 2.3), that could affect homework completion and performance, the gathering of student perceptions helped in determining whether students felt that there are associated benefits to be gained from WBH that could contribute towards improved performance in their mathematics.

4.5.2 Student Survey Construct Results and their Reliability using Cronbach's Alpha

It is essential to test the reliability of the survey in its entirety as well as the constructs it measured (Hartas, 2010). In the first instance, this was done using Cronbach's alpha, the inter-item correlation matrix and the corrected item-total correlations in SPSS. Cronbach's alpha was used to find out whether it was justifiable to interpret scores that have been aggregated together to measure constructs based on the 25-item survey inventory.

Table 18a. Case processing summary

Case Processing Summary			
		N	%
Cases	Valid	203	99.5
	Excluded	1	0.5
	Total	204	100

18b. Reliability of Student Survey using Cronbach's α.

Reliability Statistics	
Cronbach's Alpha	n of Items
0.907	25

From the case summary in Table 18a, only one participant from 204 was excluded due to a missing response to one of the statement items. In Table 18b $\alpha = .907$, which is an estimate of the internal consistency for the 25-item inventory. The alpha coefficient of 91% is a good measure for the survey in terms of its design and what it aims to measure (perceptions about mathematics WBH and PBH) and can be considered as a true score variance (Lance, Butts and Michels, 2006). A true score variance refers to the reliability of the test based on an estimate of the variance of reliable ability scores measured by a test. The inter-item correlation matrix (see Appendix 19) makes clear that all the items correlate positively with each other with all the corrected item-total correlations in the items-total statistics ranging from 0.3 to 0.7 (see Appendix 20) apart from statement item E16 (I am easily distracted when doing Online maths homework). This item if deleted, would improve the internal consistency, but it is already at an acceptable level (Ferketich, 1991).

From the reliability test of the survey, it was essential to present the results of the constructs being measured and to test their reliability, as mentioned in chapter 3 (section 3.6.9). The reliability of the constructs was also tested using Cronbach's alpha in SPSS. Cronbach's alpha was used to find out whether it was justifiable to interpret scores that have been aggregated together to measure a construct.

Table 19. Survey Construct Results Statistics

	Mean	Std. Dev	N
Construct 1: Student perceptions of how they interact with WBH compared to PBH	1.58	.657	203
Construct 2: Student perceptions of how WBH improves mathematics performance	1.62	.664	203
Construct 3: Student perceptions about their learning with WBH and PBH	1.56	.656	203

Table 19 gives the survey construct statistics results and it shows that the highest mean score is obtained for Construct 2 (*M* = 1.62; *SD* = .664), followed by the mean score for Construct 1 (*M* = 1.58; *SD* = .657) and then the mean score for Construct 3 (*M* = 1.56; *SD* = .656). The low mean scores indicate positive associations and agreement amongst the survey items put together to measure the constructs. Strong positive correlations are ranging from 0.3 to 0.7 in most cases between the survey items grouped (Ferketich, 1991). This result is supported further by the significant associations amongst all survey items put together to measure constructs one, two and three in Appendix 33. The item correlations in Appendix 33 for constructs 1, 2 and 3 indicate that there are statistically significant correlations between all the items with $p < .01$. These results suggest that constructs 1, 2 and 3 have high construct validity. The item correlations for Construct 1 shows that E1("I like to do maths homework on the computer") has the highest correlation with E2 ("Online maths homework motivates me to practice maths") with $r = .693$. E2 also shows one of the strongest correlations with item E3 ($r = .644$). Items E3 ("I like to receive immediate scores on my maths homework") and E5 ("I like the help and suggestions facility on my Online maths homework") are also strongly correlated with $r = .560$. For Construct 2, the strongest correlation is obtained between survey item E8 ("Online maths homework gives me more chances to practice mathematical topics") and E10 ("The Online lesson review helps me to review mathematics concepts") with $r = .7$, followed by a high correlation value between survey items E18 ("My parents are keener to monitor my progress in maths because of Online homework") and E19 ("I get help from my family, friends and others in completing my Online maths homework") with $r = .666$. Construct 3 shows that E13 ("I like Online maths homework more than paper-based maths homework") and E14 ("I feel I can be better at maths as a result of Online maths homework") have the highest correlation between the items with $r = .717$, followed by the correlation between E12 ("Online maths homework helps me evaluate my own understanding and performance") and E13 with $r =$

.692. So, within the 25-item inventory, the items associated with constructs 1, 2 and 3 were grouped and analysed. However, it is important to note that Cronbach's alpha is only a measure of internal consistency and not a reliable measure as to how the scale is measuring any additional isolated constructs.

Table 20. Reliability of construct 1(Students' perceptions of how they interact with WBH compared to PBH) using Cronbach's α.

Cronbach's α	*n* of items
.808	8

For construct 1 (Students' perceptions of how they interact with WBH compared to PBH) α = .808 (Table 20), which indicates 81% of the variability in a composite score, combining the eight items listed below as a measure for construct 1, can be considered as a true score variance. The inter-item correlation matrix in Table 43 makes it clear that all the items correlate positively with each other. However, in theory, it is better to have the item correlation somewhere within the 0.3 – 0.5 range to strongly support the notion that the items are measuring the same phenomenon (Hartas, 2010). The statement item E9 ("I enjoy maths homework activities Online more than on paper") scored outside of this range with statement items E3 ("I like to receive immediate scores on my maths homework"), E4 ("Immediate scores help me to be aware of my performance"), E5 ("I like the help and suggestions facility on my Online maths homework") and E17 ("I discuss my Online maths homework with my classmates and others"). These items score outside of the range because they could be saying a similar thing. However, the average inter-item correlation that is a measure of internal consistency can fall in the range of 0.15 to 0.5 (Briggs & Cheek, 1986; Clark & Watson, 1993). According to Briggs and Cheek (1986), this rather wide range suggested, is because the optimum value that is necessary will be dependent on the target construct that is measured. Therefore, even though some items may conflict with others in trying to measure the same underlying construct and fall outside the 0.3 to 0.5 range, a measure of 0.2 and above can still be considered an acceptable part of the construct's measure (Briggs and Cheek, 1986).

Table 21. Inter-Item Correlation Matrix for Construct 1

	I like to do maths homework on the computer	Online maths homework motivates me to practice maths.	I like to receive immediate scores on my maths homework.	Immediate scores help me to be aware of my performance.	I like the help and suggestions facility on my Online maths homework.	I discuss my Online maths homework with my classmates and others.	I spend more time on my maths homework because I can interact with the maths	I enjoy doing maths homework activities Online more than on paper.
I like to do maths homework on the computer	1.000	.727	.663	.266	.546	.542	.362	.317
Online maths homework motivates me to practice maths.	.727	1.000	.535	.327	.422	.380	.469	.413
I like to receive immediate scores on my maths homework.	.663	.535	1.000	.248	.397	.474	.377	.209
Immediate scores help me to be aware of my performance.	.266	.327	.248	1.000	.301	.332	.431	.229
I like the help and suggestions facility on my Online maths homework.	.546	.422	.397	.301	1.000	.317	.357	.229
I discuss my Online maths homework with my classmates and others.	.542	.380	.474	.332	.317	1.000	.338	.243
I spend more time on my maths homework because I can interact with the maths	.362	.469	.377	.431	.357	.338	1.000	.467
I enjoy doing maths homework activities Online more than on paper.	.317	.413	.209	.229	.229	.243	.467	1.000

A further investigation into the construct's internal consistency using the item-total statistics (see Table 21) suggests that the eight items are a reasonable measure for construct 1. All the items' corrected item-total correlation measures are above 0.4. This correlation measure is a Pearson correlation between the specific item measured and the sum of all the other items. If all of the items measure the same underlying construct, the expectation is that the correlation coefficient would be between 0.3 and 0.7 (Ferketich, 1991; Lance et al., 2006). Notably, Pearson correlation coefficients lower than 0.3 are usually a cause for concern, because such a value indicates that a question or statement item might not be measuring the targeted underlying construct. In this case, it might be best to remove the statement item from the construct considered.

The last section of the item-total statistics in Appendix 21 (Cronbach's alpha if item deleted) is perhaps the most important, as it suggests that if any of the items put together were to be deleted the alpha coefficient would improve. All eight statement items have a value of α > .75. According to Ferketich (1991), any alpha coefficient greater than 0.7 is more than an acceptable measure for internal consistency (Ferketich, 1991; Lance et al., 2006).

The same method for measuring the reliability of construct 1 was used for the second construct, and α = .794 for the seven items listed (see Table 22). The corrected-item total correlation measures were all above 0.4 (see Appendix 22). However, the item listed as E11 (I have less anxiety in taking Online homework than paper-based homework) in the "if item deleted" section was 0.796.

Table 22. Construct 2 (Student perceptions of how WBH improves mathematics performance) Cronbach's α.

Cronbach's α	*n* of Items
.794	7

In Table 22, the construct (Student perceptions of how WBH improves mathematics performance) shows that positive correlations are with survey items E8 ("Online maths homework gives me more chances to practice mathematics") and E10 ("The Online lesson review helps me to review maths concepts"). Participating students indicated on the survey (item E18) that their parents were keener to monitor their mathematics progress due to them spending more time interacting with the material content. Visual inspection of Table 45 suggests that the positive correlations in the inter-item correlation matrix lie between 0.3 and 0.7 which indicates that the items put together from the 25-item survey inventory are measuring the same phenomena (Hartas, 2010). Further support for this is the item total-statistics (see Appendix 22) that shows the corrected item total-correlations lie between 0.4 and 0.7, which is at an acceptable level for the construct being measured. However, statement item E11 ("I have less anxiety in taking Online homework than paper-based homework"), if deleted, would increase the internal consistency reliability associated with scores derived from the scale to .796 which is greater than the α coefficient of .794. Since this is negligible and internal consistency is already at an acceptable level, I have chosen to ignore this observation.

Table 23 Inter-Item Correlation Matrix for Construct 2.

Inter-Item Correlation Matrix							
	I refer to the Online lesson activities to help me complete my homework.	Online homework feedback helps me to recognise my mistakes	Online maths homework gives me more chances to practice mathematical topics.	The Online lesson review helps me to review mathematics concepts.	I have less anxiety in taking Online homework than paper based homework.	I get help from my family, friends and others in completing my Online maths homework	My parents are more keen to monitor my progress in maths because of Online homework.
I refer to the Online lesson activities to help me complete my homework.	1.000	.356	.576	.395	.342	.351	.295
Online homework feedback helps me to recognise my mistakes	.356	1.000	.333	.400	.316	.437	.398
Online maths homework gives me more chances to practice mathematical topics.	.576	.333	1.000	.604	.263	.340	.292
The Online lesson review helps me to review mathematics concepts.	.395	.400	.604	1.000	.212	.443	.512
I have less anxiety in taking Online homework than paper based homework.	.342	.316	.263	.212	1.000	.279	.269
I get help from my family, friends and others in completing my Online maths homework	.351	.437	.340	.443	.279	1.000	.425
My parents are more keen to monitor my progress in maths because of Online homework.	.295	.398	.292	.512	.269	.425	1.000

Finally, Table 23 has the seven items that were put together to try to get student perceptions about the third construct (i.e., student perceptions about their learning with WBH and PBH). For these items, α = .819 and again, the corrected-item total correlation measures were above .4 (see Appendix 23). All measures in the "if item deleted" section was less than the alpha coefficient.

Table 24. Construct 3 Reliability (student perceptions about their learning with WBH and PBH).

Cronbach's α	*n* of Items
.819	7

In Table 24 for construct 3, positive correlations are shown with statement items E12 ("Online maths homework helps me evaluate my own understanding and performance") and E13 ("I like Online maths homework more than paper-based homework"). Also, statement items E14 ("I feel I can be better at maths as a result of Online maths homework") correlated positively with statement item E24 ("My maths has improved as a result of Online homework"). Visual inspection of Table 47 suggests that the positive correlations in the inter-item matrix lie between 0.3 and 0.6, which indicates that the items put together from the 25-item survey inventory are measuring the same phenomena. This is further supported by the item total-statistics (see Appendix 23) that shows the corrected item total-correlations lie between 0.3 and 0.7, which is at an acceptable level for the construct being measured. Like with constructs 1 and 2 on the student survey, the item-total statistics can further support the internal consistency and reliability of the construct being measured by inspecting the corrected item-total correlation, which for construct 3 lies between 0.4 and 0.7 (see Appendix 23) which is again at acceptable levels (Ferketich, 1991; Lance et al., 2006).

In the evaluation of the coherence of the constructs, three statement items from the survey were omitted from the analysis as they were considered to be informative qualitative data that may not fit the construct design. These items were E16 ("I am easily distracted when doing Online mathematics homework"); E20 ("PBH is just as effective as Online mathematics homework") and E23 ("The use of English language for my Online mathematics homework is not a problem").

Table 25. Inter-Item Correlation Matrix for Constructure 3.

Inter-Item Correlation Matrix

	I enjoy doing maths homework activities Online more than on paper.	Online maths homework helps me evaluate my own understanding and performance.	I like Online maths homework more than paper based maths homework.	I feel I can be better at maths as a result of Online maths homework .	I am more motivated to do my maths homework on the computer than on paper.	Online maths homework is better than Paper based maths homework	My maths has improved as a result of Online homework.
I enjoy doing maths homework activities Online more than on paper.	1.000	.156	.285	.366	.398	.500	.389
Online maths homework helps me evaluate my own understanding and performance.	.156	1.000	.664	.385	.344	.299	.399
I like Online maths homework more than paper based maths homework.	.285	.664	1.000	.497	.492	.321	.527
I feel I can be better at maths as a result of Online maths	.366	.385	.497	1.000	.427	.351	.567
I am more motivated to do my maths homework on the computer than on paper.	.398	.344	.492	.427	1.000	.392	.474
Online maths homework is better than Paper based maths homework	.500	.299	.321	.351	.392	1.000	.348
My maths has improved as a result of Online homework.	.389	.399	.527	.567	.474	.348	1.000

In summary, the first construct consisted of eight items (E1-E5, E9, E17 and E25). The scale had a high level of internal consistency, as determined by $\alpha = .808$. The second construct consisted of seven items (E6-E8, E10, E11, E18 and E19) and it produced $\alpha = .794$. Finally, for the third construct (items E9, E12-E15, E21 and E24) to measure student perceptions of their learning with WBH and PBH, $\alpha = .819$. The results indicate that the survey items that were put together can be considered to have a high level of internal consistency and can, therefore, be a reliable measure of the constructs being tested. However, this must be supported by using factor analysis as we are testing for dimensionality when using the survey items to measure constructs.

4.5.3 Reliability of the Student Survey Using Factor Analysis

A factor analysis was conducted to test the reliability of the student survey constructs. The factor analysis aims to reduce the number of variable components, or statement items in this study that is associated with the constructs without compromising the meaning of the construct (Hartas, 2010).

Table 26 is a correlation matrix of the principal component analysis (PCA) for the eight variables (E1 to E5, E9, E17 and E25) in construct 1 (*student perceptions of how they interact with WBH compared to PBH*) . These variables came from the 25-item inventory on the student survey. Table 48 shows all the inter-correlations of the eight variables measuring construct 1. By visual inspection, notice that the Pearson-correlation between survey item E3 ("I like to receive immediate scores on my maths homework") and survey item E17 ("I discuss my Online maths homework with my classmates and others") as being .474 and has a double asterisk which indicates that it is statistically significant at the .01 level (2-tailed), $p < .01$. The correlations between the variables or survey items have been analysed with SPSS, and it suggests that all items are correlated with one another and at a minimum level ($p < .05$) significantly so. The factor analysis that was run in SPSS came out with two-component variables that tried to explain the correlations between the eight variables that could provide a more parsimonious solution that identifies these relationships.

Table 26. Correlation Matrix for Principal Component Analysis (construct 1)

		I like to do maths homework on the computer	Online maths homework motivates me to practice maths.	I like to receive immediate scores on my maths homework.	Immediate scores help me to be aware of my performance.	I like the help and suggestions facility on my Online maths homework.	I enjoy doing maths homework activities Online more than on paper.	I discuss my Online maths homework with my classmates and others.	I spend more time on my maths homework because I can interact with the maths
I like to do maths homework on the computer	Pearson Correlation	1	.727**	.663**	.266**	.546**	.317**	.542**	.362**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	204	204	204	204	204	204	204	204
Online maths homework motivates me to practice maths.	Pearson Correlation	.727**	1	.535**	.327**	.422**	.413**	.380**	.469**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000	0.000
	N	204	204	204	204	204	204	204	204
I like to receive immediate scores on my maths homework.	Pearson Correlation	.663**	.535**	1	.248**	.397**	.209**	.474**	.377**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.003	0.000	0.000
	N	204	204	204	204	204	204	204	204
Immediate scores help me to be aware of my performance.	Pearson Correlation	.266**	.327**	.248**	1	.301**	.229**	.332**	.431**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.001	0.000	0.000
	N	204	204	204	204	204	204	204	204
I like the help and suggestions facility on my Online maths homework.	Pearson Correlation	.546**	.422**	.397**	.301**	1	.229**	.317**	.357**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.001	0.000	0.000
	N	204	204	204	204	204	204	204	204
I enjoy doing maths homework activities Online more than on paper.	Pearson Correlation	.317**	.413**	.209**	.229**	.229**	1	.243**	.467**
	Sig. (2-tailed)	0.000	0.000	0.003	0.001	0.001		0.000	0.000
	N	204	204	204	204	204	204	204	204
I discuss my Online maths homework with my classmates and others.	Pearson Correlation	.542**	.380**	.474**	.332**	.317**	.243**	1	.338**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		0.000
	N	204	204	204	204	204	204	204	204
I spend more time on my maths homework because I can interact with the maths	Pearson Correlation	.362**	.469**	.377**	.431**	.357**	.467**	.338**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	N	204	204	204	204	204	204	204	204

**indicates statistical significance at the .01 level (2-tailed)

A principal component analysis (PCA) was run on an eight-item construct from the student survey in SPSS. The construct measured Students' perceptions of how they interact with WBH compared to PBH; The suitability of PCA was assessed prior to analysis. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3 (see Table 26). The overall Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.812 with individual KMO measures all greater than 0.7, classifications of 'middling' to 'meritorious' according to Kaiser (1974). Bartlett's test of sphericity (see Table 49) was statistically significant ($p < .05$), indicating that the correlations in Table 48 taken as a group, significantly differ from 0 and that there is at least one significant correlation between two or more items (the correlation matrix is significantly different from an identity matrix). The data indicates that it is likely to be factorisable. This means that the variables put together to measure the construct can be reduced to just one or a few factors that can best describe the construct being measured. In SPSS, this is done by extracting any variable that records an Eigenvalue greater than one.

Table 27. Bartlett's Test of Sphericity construct 1

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.812
Bartlett's Test of Sphericity	Approx. Chi-Square	607.278
	df	28
	Sig.	.000

In Table 28, the PCA in SPSS revealed two components that had Eigenvalues greater than one and which explained 47.5% and 13% of the total variance, respectively.

Table 28. PCA Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.797	47.466	47.466	3.797	47.466	47.466	2.913	36.407	36.407
2	1.044	13.047	60.512	1.044	13.047	60.512	1.928	24.105	60.512

Visual inspection of the scree plot in figure 16 further indicated that two components should be retained (Cattell, 1966). In addition, a two-component solution met the interpretability criterion of having an Eigenvalue greater than one, and as such, two components were retained.

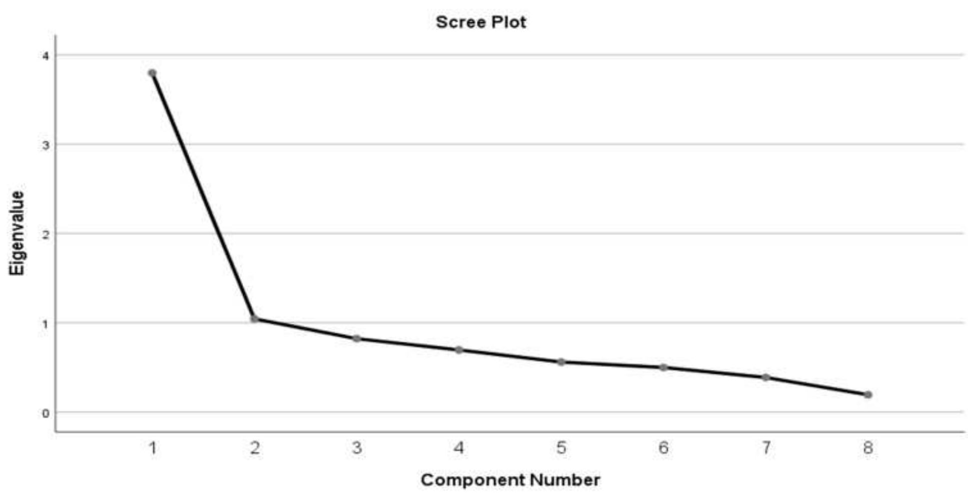


Figure 16. Scree Plot Construct 1

The two-component solution explained 60.512 % of the total variance. A Varimax orthogonal rotation was employed to aid interpretability after checking the component correlation matrix in Table 29. The PCA extraction method generated a value of 0.492, which is close to the benchmark of 0.5 but is not greater than 0.5 (Pituch and Stevens, 2015). Therefore, we can assume that the correlation relationship is orthogonal and not oblique.

Table 29. Component correlation matrix for Construct 1

Component	1	2
1	1.000	.492
2	.492	1.000

Table 30. Rotated component matrix for construct 1

Rotated Component Matrix

	Component	
	1	2
I like to do maths homework on the computer	.895	
I like to receive immediate scores on my maths homework.	.821	
Online maths homework motivates me to practice maths.	.699	
I discuss my Online maths homework with my classmates and others.	.650	
I like the help and suggestions facility on my Online maths homework.	.621	
I spend more time on my maths homework because I can interact with the maths		.782
I enjoy doing maths homework activities Online more than on paper.		.758
Immediate scores help me to be aware of my performance.		.651

In Table 30, the rotated solution exhibited 'simple structure' as each variable is loaded on to one component factor (Thurstone, 1948). The interpretation of the data was consistent with the perceived interaction effects the survey was designed to measure with strong loadings of interaction and motivation on component's one and two. However, when we check the Cronbach's alpha for the reliability of each of the weighted components, the five weighted

items on component 1 and the three weighted items on component 2, only component 1 has $\alpha > 0.7$. With an α coefficient of 0.781 in Table 31a, it suggests that these five statement-items E1, E3, E2, E17 and E5 respectively is a reliable measure of student perceptions about the interaction effects of WBH compared to PBH.

Table 31*a. Reliability Analysis Construct 1*

Table 31b. Reliability Analysis Construct 1

Reliability Statistics

Cronbach's Alpha	N of Items
.781	5

Reliability Statistics

Cronbach's Alpha	N of Items
.631	3

The three statement-items that are associated with component 2 in Table 31b achieved an α coefficient of < 0.7. This result indicates that after extraction, these 3 statement items had little effect on the construct being measured. When all eight items were put together α = .808 (see Table 26), therefore, the statement items that have been put together for construct 1 (student perceptions of how they interact with WBH compared to PBH) is a suitable measure and can be named, "perceptions of interaction with WBH compared to PBH".

Table 32. Correlation Matrix for Principal Component Analysis (Construct 2)

Correlations

		I refer to the Online lesson activities to help me complete my homework.	Online homework feedback helps me to recognise my mistakes	Online maths homework gives me more chances to practice mathematical topics.	The Online lesson review helps me to review mathematics concepts.	I have less anxiety in taking Online homework than paper based homework.	My parents are more keen to monitor my progress in maths because of Online homework.	I get help from my family, friends and others in completing my Online maths homework
I refer to the Online lesson activities to help me complete my homework.	Pearson Correlation	1	.356**	.576**	.395**	.342**	.295**	.351**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000
	N	204	204	204	204	204	204	204
Online homework feedback helps me to recognise my mistakes	Pearson Correlation	.356**	1	.333**	.400**	.316**	.398**	.437**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000
	N	204	204	204	204	204	204	204
Online maths homework gives me more chances to practice mathematical topics.	Pearson Correlation	.576**	.333**	1	.604**	.263**	.292**	.340**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000
	N	204	204	204	204	204	204	204
The Online lesson review helps me to review mathematics concepts.	Pearson Correlation	.395**	.400**	.604**	1	.212**	.512**	.443**
	Sig. (2-tailed)	0.000	0.000	0.000		0.002	0.000	0.000
	N	204	204	204	204	204	204	204
I have less anxiety in taking Online homework than paper based homework.	Pearson Correlation	.342**	.316**	.263**	.212**	1	.269**	.279**
	Sig. (2-tailed)	0.000	0.000	0.000	0.002		0.000	0.000
	N	204	204	204	204	204	204	204
My parents are more keen to monitor my progress in maths because of Online homework.	Pearson Correlation	.295**	.398**	.292**	.512**	.269**	1	.425**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000
	N	204	204	204	204	204	204	204
I get help from my family, friends and others in completing my Online maths homework	Pearson Correlation	.351**	.437**	.340**	.443**	.279**	.425**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	
	N	204	204	204	204	204	204	204

**. Correlation is significant at the 0.01 level (2-tailed).

Table 32 is a correlation matrix of the principal component analysis of the seven-survey statement items (E6, E7 E8, E10, E11, E18 and E19) in construct 2 (*student perceptions of how WBH improves mathematics performance*). These variables come from the 25-item inventory on the student survey. Table 32 shows all the inter-correlations of the seven variables that tried to measure, construct 2. By visual inspection, the Pearson-correlation between survey item E8 ("Online maths homework gives me more chances to practice mathematical topics") and survey item E10 ("The Online lesson review helps me to review mathematical concepts") as being .604 and has a double asterisk which indicates that it is statistically significant at the .01 level (2-tailed), $p < .01$. The correlations between the variables or survey items were analysed, and the results suggest that all items are correlated with one another and at a minimum level significantly so. The factor analysis that was run in SPSS came out with one variable that tried to explain the correlations between the seven variables that could provide a more succinct solution that could explain these relationships.

A PCA was run on the seven-item construct from the student survey in SPSS. The construct measured student perceptions of whether WBH improves mathematics performance. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3 (see Table 32). The overall KMO measure of sampling adequacy was 0.799 (see Table 33), and Bartlett's test of sphericity was statistically significant ($p < .05$), indicating that the correlations in Table 33 taken as a group significantly differ from 0 and that there is at least one significant correlation between two or more of the items.

Table 33. Bartlett's Test of Sphericity for Construct 2

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.799
Bartlett's Test of Sphericity	Approx. Chi-Square	411.431
	df	21
	Sig.	.000

In Table 34 the PCA in SPSS revealed one component that had an Eigenvalue greater than one and which explained 46.7% of the total variance.

Table 34. Total Variance Explained for Construct 2

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.266	46.664	46.664	3.266	46.664	46.664

Visual inspection of the scree plot in figure 17 further indicated that only one component should be retained as there was one Eigen-value greater than one and the component solution met the interpretability criterion (Cattell, 1966).

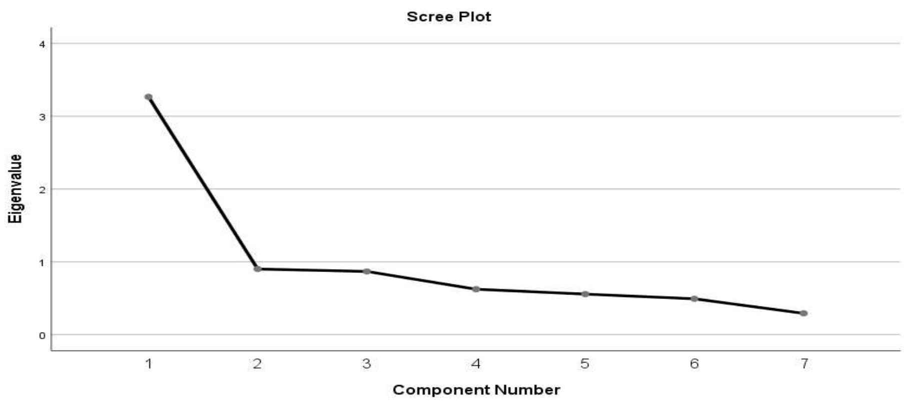


Figure 17. Scree Plot for Construct 2

Since only one component was extracted from the seven variables in SPSS, no rotation was performed. Visual inspection of the component matrix in Table 35 shows how each individual variable or survey statement item weighed on the extracted component. These factor loadings tell us how strong the item is with our component solution. Therefore, statement item E6 ("The Online lesson review helps me to review mathematics concepts") has the highest loading of 0.77 on the component. All values attained in Table 35 are greater than 0.5, which indicates that the survey items do a good job in explaining the one extracted component or factor. Based on student perceptions, the survey statement items that have been grouped under the one component factor seems to indicate that it is a reasonable measure for the construct, of how WBH can improve mathematics homework performance. The construct can then be named perceptions on improved mathematics performance.

Table 35. Component Matrix for Construct 2

Component Matrix	
	Component 1
The Online lesson review helps me to review mathematics concepts.	0.770
Online maths homework gives me more chances to practice mathematical topics.	0.732
I refer to the Online lesson activities to help me complete my homework.	0.699
I get help from my family, friends and others in completing my Online maths homework	0.688
Online homework feedback helps me to recognise my mistakes	0.676
My parents are keener to monitor my progress in maths because of Online homework.	0.668
I have less anxiety in taking Online homework than paper-based homework.	0.521

Table 36 is a correlation matrix of the principal component analysis for the six variables (E9 to E12, E13, E15, E21 and E24) in construct 3 (*student perceptions of their learning with WBH and PBH*) . The same method of analysis is used as in constructs 1 and 2. Table 36 shows all the inter-correlations of the six variables that try to measure construct 3. By visual inspection, notice that the Pearson-correlation between survey item E12 ("Online maths homework helps me evaluate my own understanding and performance") and survey item E13 ("I like Online maths homework more than paper based maths homework") as being .665 and has a double asterisk which indicates that it is statistically significant at the .01 level (2-tailed), $p < .01$. The correlations between the variables or survey items have been analysed with SPSS, and it suggests that all items are correlated with one another and at a minimum level significantly so. The factor analysis that was run in SPSS came out with two-component variables that tried to explain the correlations between the six variables. This explanation could provide a more parsimonious solution that explains the relationship between the six variables or survey statement items and the two extracted components or factors.

Table 36 Correlation Matrix for Principal Component Analysis (construct 3)

Correlations

		I enjoy doing maths homework activities Online more than on paper.	Online maths homework helps me evaluate my own understanding and performance.	I like Online maths homework more than paper based maths homework.	I am more motivated to do my maths homework on the computer than on paper.	Online maths homework is better than Paper based maths homework	My maths has improved as a result of Online homework.
I enjoy doing maths homework activities Online more than on paper.	Pearson Correlation	1	.157*	.286**	.398**	.501**	.390**
	Sig. (2-tailed)		0.025	0.000	0.000	0.000	0.000
	N	204	204	204	203	204	204
Online maths homework helps me evaluate my own understanding and performance.	Pearson Correlation	.157*	1	.665**	.344**	.300**	.400**
	Sig. (2-tailed)	0.025		0.000	0.000	0.000	0.000
	N	204	204	204	203	204	204
I like Online maths homework more than paper based maths homework.	Pearson Correlation	.286**	.665**	1	.492**	.322**	.527**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000
	N	204	204	204	203	204	204
I am more motivated to do my maths homework on the computer than on paper.	Pearson Correlation	.398**	.344**	.492**	1	.392**	.474**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000
	N	203	203	203	203	203	203
Online maths homework is better than Paper based maths homework	Pearson Correlation	.501**	.300**	.322**	.392**	1	.350**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000
	N	204	204	204	203	204	204
My maths has improved as a result of Online homework.	Pearson Correlation	.390**	.400**	.527**	.474**	.350**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	
	N	204	204	204	203	204	204

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3 (see Table 36). The overall Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.773 (see Table 37). Bartlett's test of sphericity was statistically significant ($p < .05$), indicating that the correlations in Table 37 taken as a group significantly differ from 0 and that there is at least one significant correlation between two or more items. The data indicated that it is likely to be factorisable.

Table 37. Bartlett's Test of Sphericity construct 3

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.773
Bartlett's Test of Sphericity	Approx. Chi-Square	380.864
	df	15
	Sig.	.000

In Table 60 the PCA in SPSS revealed two components that had Eigenvalues greater than one and which explained 50.2 %, and 17.7 % of the total variance, respectively.

Table 38. PCA Total Variance Explained Construct 3

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.012	50.199	50.199	3.012	50.199	50.199
2	1.062	17.703	67.901	1.062	17.703	67.901

Visual inspection of the scree plot in figure 18 further indicated that two components should be retained (Cattell, 1966). Also, a two-component solution met the interpretability criterion of having Eigenvalues greater than one, and as such, two components were retained.

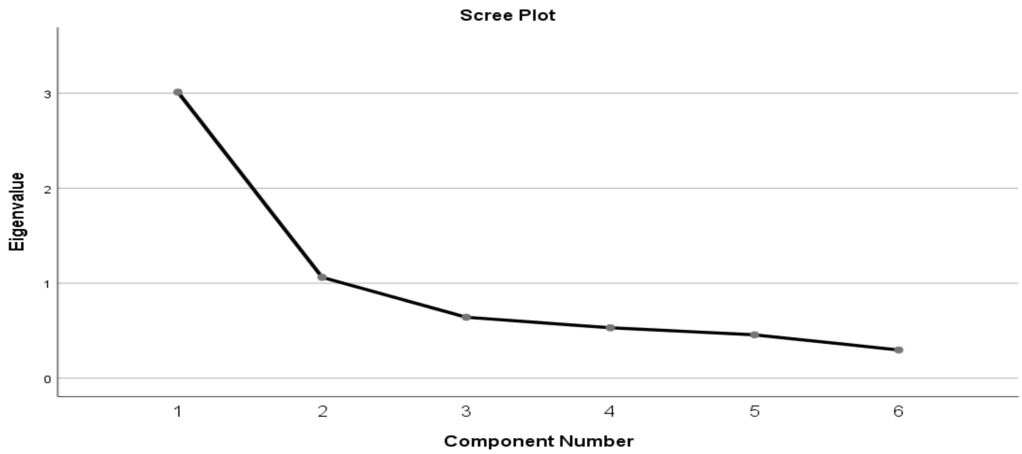


Figure 18. Scree Plot Construct 3

The two-component solution explained 67.901 % of the total variance. A Varimax orthogonal rotation was employed to aid interpretability after checking the component correlation matrix in Table 39. The PCA extraction method generated a value of 0.388, which is not greater than 0.5. Therefore, we can assume that the correlation relationship is orthogonal and not oblique.

Table 39. Component Correlation Matrix Construct 3

Component	1	2
1	1.000	.388
2	.388	1.000

Table 40. Rotated component matrix for construct 3

Rotated Component Matrix[a]

	Component	
	1	2
Online maths homework helps me evaluate my own understanding and performance.	0.875	
I like Online maths homework more than paper based maths homework.	0.871	
My maths has improved as a result of Online homework.	0.589	0.465
I enjoy doing maths homework activities Online more than on paper.		0.869
Online maths homework is better than Paper based maths homework		0.770
I am more motivated to do my maths homework on the computer than on paper.	0.494	0.554

In Table 40 the rotated solution exhibited some 'simple structure' (Thurstone, 1948). However, there were factor loadings on more than one variable. The interpretation of the data was consistent with the perceived improvement in mathematics homework performance the survey was designed to measure, with strong loadings of evaluation, understanding and maths improvement on component's one and two. There are three items from the six that measure WBH or PBH preference. When we check the Cronbach's alpha for the reliability of each of the weighted components, the four weighted items on each of the components has $\alpha > 0.7$. With an α coefficient of 0.787 in Table 41, it suggests that these four statement-items E12, E13, E24 and E15 respectively for component (1) is perhaps a reasonable measure for student perceptions about their learning in mathematics using Web-based and PBH.

Table 41. Reliability Analysis for Construct 3(component 1)

Reliability Statistics	
Cronbach's Alpha	N of Items
.787	4

The four statement-items that are associated with component (2) in Table 42 achieved an α coefficient of .733. This α coefficient is slightly similar but smaller than the alpha measure in Table 41.

Table 42. Reliability Analysis for Construct 3(component 2)

Reliability Statistics	
Cronbach's Alpha	N of Items
.733	4

Since statement items are similar and are trying to measure the same underlying construct of student perceptions of their learning with WBH and PBH, we can name the factor as perceptions of mathematics learning with Web-based and PBH.

I measured three constructs from the student survey. However, five-component factors emerged when analysing the three survey constructs and their variables in SPSS. A further check with the entire survey with two statement items removed E16 ("I am easily distracted when doing Online maths homework") and item E21 ("Online maths homework is better than Paper based maths homework") due to the alpha coefficients being greater and, therefore, a more reliable measure of the constructs being measured was performed in SPSS.

Table 43. Total Variance Explained for all Survey Items

Total Variance Explained									
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.492	41.271	41.271	9.492	41.271	41.271	3.480	15.132	15.132
2	1.500	6.521	47.791	1.500	6.521	47.791	3.212	13.965	29.097
3	1.389	6.039	53.831	1.389	6.039	53.831	3.095	13.457	42.555
4	1.332	5.792	59.623	1.332	5.792	59.623	2.477	10.768	53.322
5	1.015	4.414	64.037	1.015	4.414	64.037	2.464	10.715	64.037

In Table 43 the PCA in SPSS revealed five components that had Eigenvalues greater than one and which explained 64.037% of the total variance. A Varimax orthogonal rotation was employed to aid interpretability after checking the component correlation matrix.

The rotated solution (see Appendix 24), exhibited a few complex variables loaded on more than one component (Thurstone, 1948). However, the interpretation of the data was consistent with the perceived mathematics homework interaction; perceived benefits WBH has on student learning that possibly emerged as a result of improved mathematics homework performance and on the student's perceptions about their mathematics learning with Web-based and PBH. These were the constructs that the survey was designed to measure. There were strong loadings of perceived homework improvement on component 1, in Appendix 24. The matrix showed seven loadings greater than 0.4, which was pre-set in SPSS as a good value for minimum loading of a variable or item onto a factor (Bunz, 2010). Survey statement item E14 ("I feel I can be better at maths as a result of Online maths homework") was the highest weighted variable on the first factor (component 1) with a correlation coefficient of 0.715. The second item E24 ("My maths has improved as a result of Online homework") contributed towards defining the factor with the five other survey items under the component.

Component two had six weighted items that emphasised homework interaction (see Appendix 24). Survey statement items E21 ("Online maths homework helps me evaluate my own understanding and performance") and E3 ("I like to receive immediate scores on my maths homework") weighted highly on the factor with coefficients of .694 and .659 respectively. The variable items grouped for component two were associated with student perceptions of their interaction with WBH.

Components three, four and five had five weighted items each and the top two survey statement items E19 ("I get help from my family, friends and others in completing my Online maths homework"), E9 ("I enjoy doing maths homework activities Online more than on paper"), E23 ("My teacher encourages the use of Online maths homework"), E4 ("Immediate scores help me to be aware of my performance"), E6 ("I refer to the Online lesson activities to help me complete my homework"), and E8 ("Online maths homework gives me more chances to practice mathematical topics") weighted highly for each of the remaining component factors. Component three suggested the variable items were student perceptions about how they have improved when completing the mathematics homework; component four and five were suggestive of how students perceive WBH develops mathematics homework performance and homework interaction. Even though an orthogonal, uncorrelated technique in SPSS was used, it does not mean that some survey items grouped were not measuring a similar construct. Visual inspection of the correlation matrix does indicate that some statement items are significantly correlated with items that are measuring another construct. Some complex variables appear in more than one component (survey items E1, E2, E8, E13 and E25). When we check the Cronbach's alpha for the reliability of each of the weighted components, the four weighted items on each of the components has $\alpha > 0.7$. With an α coefficient of 0.787 in Table 63, it suggests that these four statement-items E12, E13, E24 and E15 respectively, is perhaps a reasonable measure for student perceptions about their learning with WBH and PBH.

Table 44. Reliability Analysis of student Survey Factors 1 to 5

	Cronbach's Alpha	n of Items
Factor 1	0.870	7
Factor 2	0.781	6
Factor 3	0.786	5
Factor 4	0.748	5
Factor 5	0.819	5

The weighted statement-items that are associated with components one to five in Table 66 achieved α coefficients of .870, .781, .786, .748 and .819, respectively. Since some statement items are similar and are trying to measure the same underlying construct of student perceptions of homework interaction, performance and about their learning with Web-based and PBH, it is essential to look at the extracted component factors with some caution as some correlations do exist, and the likelihood is that they will overlap and measure similar constructs. As mentioned earlier, I used three constructs to measure student perceptions from the survey. However, five-component factors emerged when analysing the three constructs in SPSS. This happened in both the construct cases (construct 1 to 3) and in the analysis of the entire student survey. It suggests that there is an element of consistency about the constructs used to measure student perceptions of their experiences with WBH and

PBH from the survey, even though some of the component items (survey statement items) may have been better suited elsewhere.

Further tests were conducted to see if the data could be simplified further. Statement item E22 ("The use of English language for my Online maths homework is not a problem") was taken out as it could improve the survey. Direct Oblimin and Promax rotations were investigated with factor loadings set at the 0.4 level, and component loadings were reduced to four. Direct Oblimin was unable to load and the Promax loadings exhibited a structure similar to that of the 23-item survey inventory in Appendix 24. The pattern matrix loadings that uses regression coefficients suggested that survey items E1, E2, E3 , E7, E12 and E17 (see Appendix 16 for names of listed survey items E1 – E25) could be used as a measure for the construct of homework interaction (see Appendix 29). For these six items, the reliability alpha coefficient is .833. Factor loadings of E5, E8, E10, E12, E13, E14 and E15 could be used as a measure for student perceptions on WBH and mathematics performance with statement item E8 ("Online maths homework gives me more chances to practice mathematical topics") recording a coefficient score of .905. For these seven items, the reliability alpha coefficient is .865. The third component loading suggested that survey items E9, E15, E18, E19, E24 and E25 were a suitable measure for student perceptions about their learning with Web-based and PBH. For these six items, the reliability alpha coefficient is .814. However, statement items E4, E11, E20, E23, E25 were loaded onto a fourth component and were also associated with student perceptions about their learning with Web-based and PBH (see Appendix 29). For these five items, the reliability alpha coefficient is .752. These results tell us that the Promax rotation used provides a slightly firmer structure as to how the survey items that measured the constructs could have possibly been better grouped. However, when I looked at the structure matrix in SPSS to double-check the loadings after rotation, several complex variables were loaded onto more than one factor which can make the analysis and naming of the variable construct complicated (Hartas, 2010).

4.5.4 Student Interviews

The organisation of the student participants' experiences into themes using the NVivo software helped to generate four main parent categories. The key themes are listed below, with their child themes or sub-themes. The analysis of content focussed on the frequent usage of keywords amongst the interview participants. The NVivo software was able to facilitate the process of identifying key important themes via a text search frequency query. The search told me the number of times a word or phrase was used in the transcribed data. It also gave me associated words and phrases that were synonymous with keywords and themes.

Figure 19 illustrates an NVivo output of a word cloud that illustrated the frequency of the word usage, the bigger the font size, the greater the frequency.

Figure 19. NVivo word cloud to generate possible themes and sub-themes

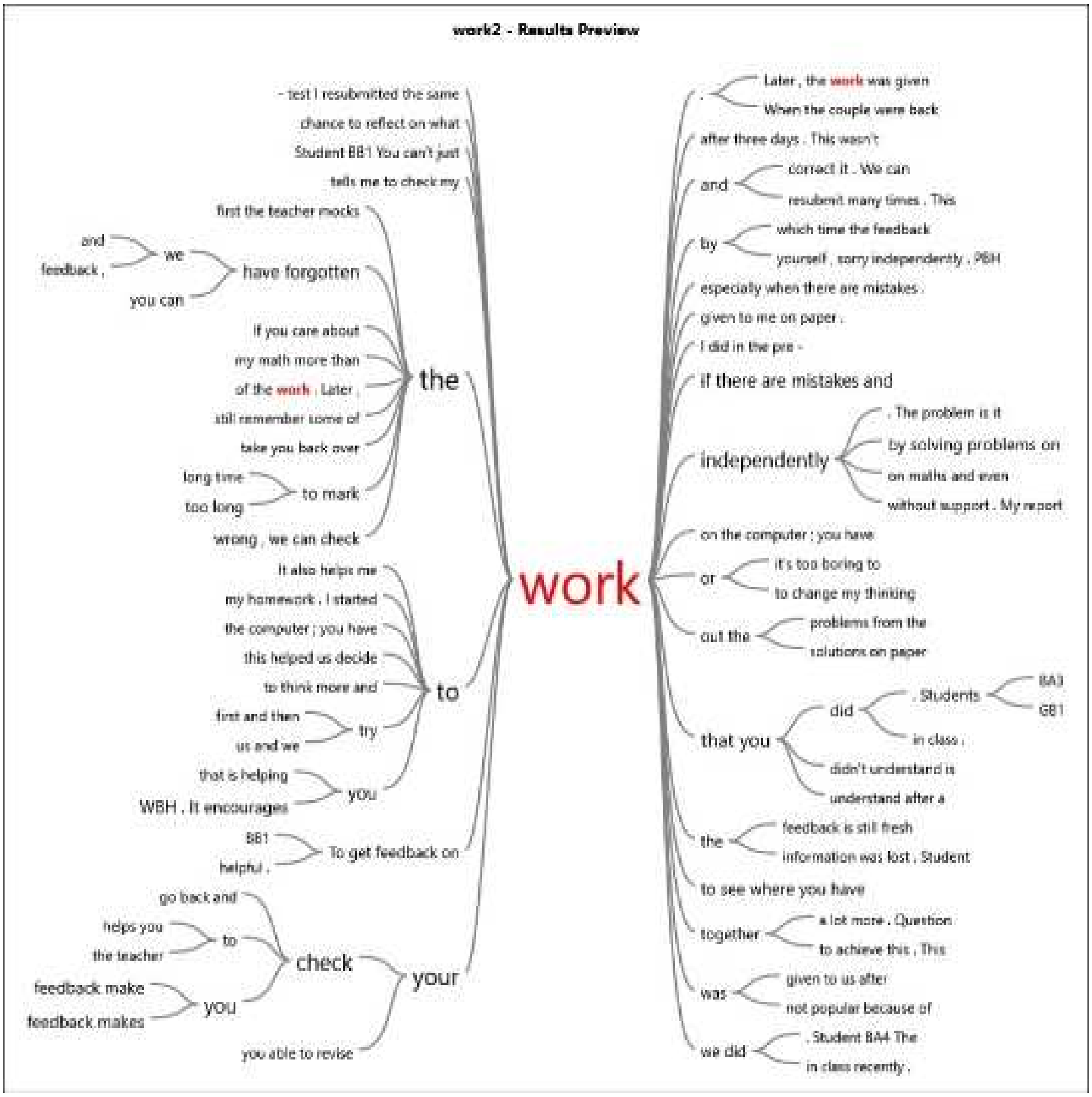


Figure 20. Word tree generating sub-themes and categories

Figure 20 shows that in addition to the word cloud, there is a word tree facility in NVivo that depicts a high-frequency word that could be viewed as an associated theme or possible sub-theme with the words used in conjunction, before and after it. For example, the word "work" was associated with branches of other words, clauses and phrases that helped to support the extracted themes. The interview transcript was divided into four themes to help support and answer the RQ. These themes are presented in Table 67.

Table 45. Key Themes from the Interview Transcript.

Key themes	Sub-themes
1. Communication with the technology and peers	Interaction with classmates, family and others
2. Engagement with technology, peers and others	Student perceptions as to their working at levels when completing WBH in comparison to PBH
3. Feedback from the technology, peers and others	Instant feedback and the marks associated with the completed work
4. Metacognition	Revised thinking and the reviewing of mathematical content material

Table 67 is a matrix mapping of emergent themes that came from a frequency word-search query. The query was formulated in the form of a word cloud or tree and then considered in relation to the interview and RQ. Memos were made about the meaning of these words and their associated words. They were then considered for themes and sub-themes. The interview questions were then mapped to the RQ in an attempt to generate the data in a consistent manner that could address the objectives of this study. The key themes were generated to address the RQ (as mentioned in Section 3.6.10). Some of the emergent themes overlap with each other, such as communication and engagement. Communication is considered in the context of students interacting with the tool, material content, their peers, and others. It is fair to say that multiple variables are considered here. Engagement is considered in reference to the time spent on homework and the students' perception of quality and benefit with regard to WBH and PBH.

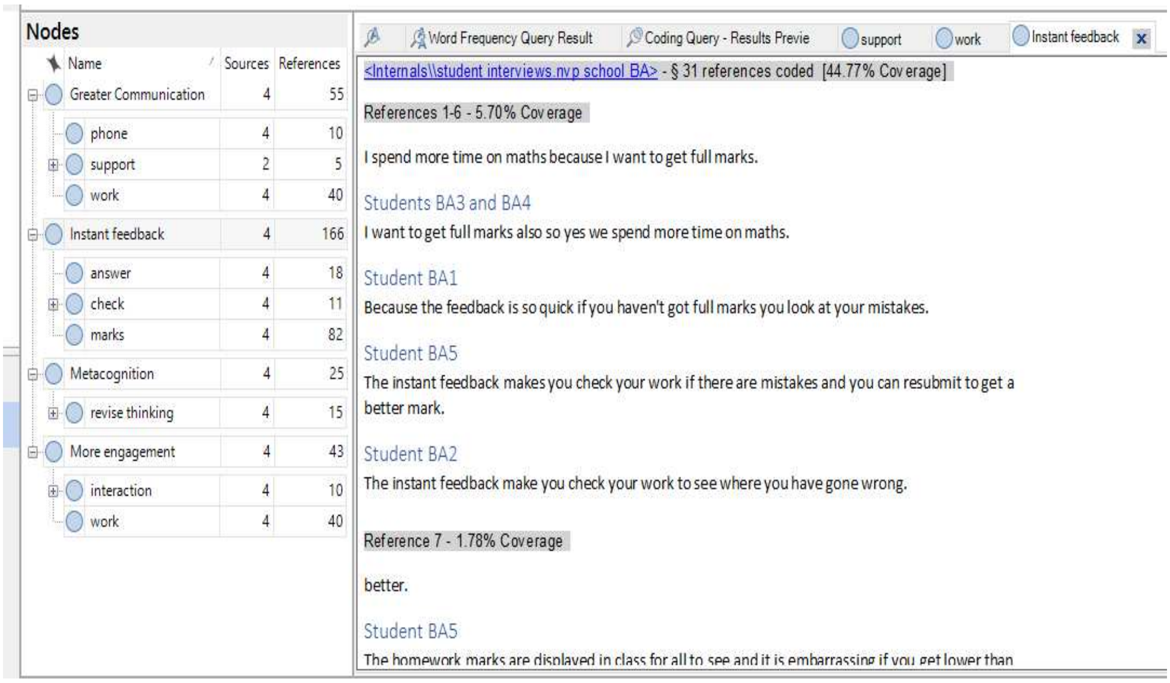


Figure 21. Evidence of coding using the drag and drop method in NVivo.

Figure 21 shows how referenced student responses were highlighted and then dragged and dropped into the themes and sub-themes of the parent nodes. The "Source" indicates the number of interviews where the themes and sub-themes were coded. The "References" indicate the frequency of the word usage across the interviews. For example, under the parent node "instant feedback", the word "marks" was used 82 times across all four schools. This indicates that the marks or homework scores were important to the participating students.

The interview data were examined for frequently occurring words relating to the four identified themes listed above in Table 67: greater communication, instant feedback, metacognition, and more engagement.

Table 68 below offers a breakdown of the most frequently occurring words used in the final interview transcript. The analysis of the transcripts was done instead of analysing the recorded interview because of language issues. Some of the participating students were more comfortable speaking in Arabic; therefore, it was necessary for reasons of equity to allow for this process to happen. The recorded interviews were then translated and transcribed. The quality of the translation was checked and verified by an Arabic specialist teacher who is proficient in the use of the English language. This provided some assurance that the translation was accurate and consistent enough to go ahead and use a word search method to assist with the analysis of the data.

Table 46. Associated keywords with a frequency greater than 100

Word	Word Count	Weighted %
Homework	171	2.48
PBH	150	2.17
Feedback	132	1.91
Get	126	1.83
Marks	120	1.74
WBH / online homework	110	1.59

The total occurrences of keywords are shown in Table 68 (frequency > 100). The occurrences of keywords used more than 100 times include "homework" (n = 171), "paper-based homework" (n = 150), "feedback" (n = 132), "get" (in reference to what students received for their WBH score; (n = 126), "marks" (n = 120) and "Online homework" (n = 110). The weighted percentage assigns a part of the word's frequency usage within the transcript.

The job of coding the interview transcripts resulted in a total of 661 references to the four main categories listed above (i.e., greater communication, instant feedback, metacognition, and more engagement). The coded references were grouped into four categories interpreted to have addressed the semi-structured interview questions. Also, some sub-categories included language usage, synonymous with the themes of the main categories. These subsections or words were also recorded and analysed.

Table 47. Coded Categories in NVIVO

Categories	Associated words	Coded units/Frequency in interview transcript
Communication	Phone (10)	10
Feedback	Marks	60
Metacognition	Revise thinking (54)	44
Engagement	Work (112)	81

In Table 69, only a selection of the keywords was used from those identified in NVivo. The total word count for the interview transcript is 7,171 words. The coding of the transcript in NVivo resulted in 309 references to the four core themes. In Table 69, there were associated references to categories of the themed data, such as using the phone and talking to colleagues, siblings, parents, and others: "Feedback" was the second-most frequently used word amongst the sampled participating students. Feedback was used 60 times. With the word "metacognition", students regularly used the term "revised thinking", which was used 54 times when answering WBH mathematics questions. With "engagement", the associated word "work" was used 112 times. The evidence of this coding is given in Appendix 26. Appendix 26 illustrates how the students' experiences with their assigned homework task (WBH or PBH) can be used to address RQ2.

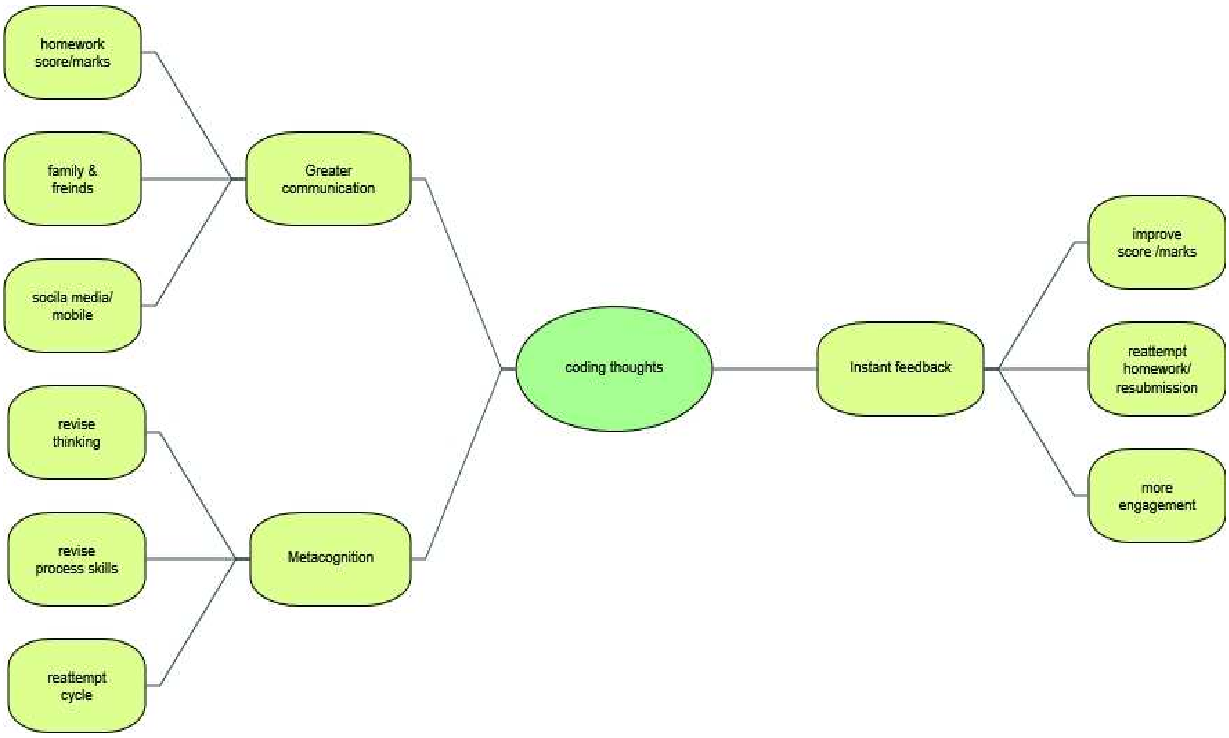


Figure 22. Initial coding thoughts on emergent themes from the student interview transcript.

Figure 22 presents an initial mapping of the keywords that emerged from the search query that was related to the interview questions and RQ2 (What are student perceptions of their learning with WBH and PBH?). The results show that the students felt that they communicated more with the WBH tasks than with the PBH. They perceived that due to the immediacy of the feedback, they were far more inclined to improve their score if they did not get full marks on their first attempt. They acknowledged that this behaviour was different from their behaviour when completing PBH. Students with PBH were less inclined to check mathematical processes and procedures with their friends via social media or the use of their mobile devices. Sometimes, with their PBH they would get the help of a family member, peer, or friend, but the transcript notes suggest that they were more inclined to do this with the availability and use of technology with their WBH. Instant feedback is aligned to the right in Figure 22, because it was perceived as the key component and feature of WBH that possibly motivated students to communicate more and to drive them towards achieving a higher score. This impetus engaged the student in more work that encouraged a homework re-attempt cycle to try to achieve a higher score. The interview responses related this to the student becoming more engaged in mathematical procedures by checking their results or, through communication, revising their steps and mathematical process skills. These responses are discussed in the following chapter when we look at participant student experiences in each of the main themed areas. From the emergent themes, it is noticeable that there is an interconnectedness amongst them. With the availability of immediate feedback, all the other themes and sub-themes are far more employable. Immediate feedback played a functional role in assisting and developing the student's attitude towards homework completion and according to their perceptions, towards the improvement of their mathematical performance, or at the very least a contributory factor in improving their mathematics homework score. For example, Student BA3 said, "The biggest difference is the availability of feedback straight away. This tells us if we are right or wrong. If we are wrong, we can check the work and correct it. We can straight away go to our notes, or we can use the help feature." Student GA3 said, "WBH helps you to practice more math because it is interactive, and the feedback is instant. Because the feedback is instant, the time spent on math homework is of better quality." Student GA2 said, "I could revise and practice more math content on the website Myimaths because of immediate feedback. In each homework task, I wanted to get the highest mark of 100%. When my parents saw this, they were always impressed. This helped to motivate me to do more mathematics tasks on the computer."

Appendix 26 gives an example of how the interview data were coded and used to discover common themes in the lived experiences of the participating students. The highlighted coding is indicative of the frequency at which the keyword was used in the sentence or phrase. Their responses to the interview questions (see Appendix 27) were as a direct result of their own learning experiences, which took place with the assigned homework task (WBH or PBH). Their perceptions of their experiences with the mathematics homework delivery methods were recorded and then viewed in line with the RQs. The emergent themes (i.e., mathematics communication, instant feedback, metacognition, and mathematics engagement) are used in a three-step process of analysis, as follows:

1. theme,
2. RQ, and
3. student perception.

4.5.5 Student perceptions of mathematics communication

> "There was more interaction with our classmates when doing the homework task. We would phone each other to check on the processes used in order to get the correct answer. This is because the answer was given to us when we checked "mark it". This helps us to change our thinking." (Students BA3 and BA4 in agreement)

Students expressed that they were motivated to get the highest marks that they possibly could with the tool, and this seemed to increase their ability to communicate not only with their peers but with other parties such as family members and friends.

> "I'm often on the phone to my friend in the class who can help me if I need it. We share answers and we learn together." (Student BB1)

The sharing of answers and information on how to improve the marked score was important to students. This collaborative behaviour seemed perfectly acceptable and reasonable to the students as a method for some to improve their homework scores. However, a few students did relate this behaviour as a way to improve their mathematical thinking. For example, Students GA3 and GA6 stated the following:

> "The communication helped with thinking. For example, after completing a question my friend told me how to check it without having to start the whole login process again.
>
> This way, you couldn't see how many times I completed the task. I think it's a good thing to be allowed multiple submissions." (Students GA3 and GA6 in agreement)

It is this form of collaboration that addresses new areas in the study of WBH versus PBH. If the revised thinking helped to support the learning and development of mathematical procedures and processing skills, then WBH needs to be used and explored in greater depth. Table 70 marks the start of the summary tables that tells the story of the findings in a linear way. The theme (T1) of communication has already been introduced above but is yet further evidenced in the table.

4.5.6 Student perceptions of homework interaction – Summary Table 1

In Table 70, communication was perceived by the participating students as being an essential facet in the success of WBH. The majority felt that WBH allowed them to interact with their class peers, friends, and family far greater than PBH. Interaction with the tool was also positive, with instant feedback being the strongest form of communication. Theme 1 (T1) has linked evidence that suggests students spent more time communicating about their WBH with their classmates than with traditional PBH. There is any number of reasons as to why this is. However, students in this study mentioned that they shared strategies and were in pursuit of full marks, and communication about the WBH task became more interesting than their experience with PBH.

Theme: Communication

Table 48. Summary Table 1- Student perceptions of homework interaction

Research question (RQ)	Interview question (IQ)	Theme (T)	Meaning	Evidence
RQ1 Do students interact more with WBH than with PBH?	IQ2 What influenced the changes as to how you learnt with WBH since you started using it?	T1 Communication	The data reviewed suggested that students who access WBH tasks are more likely to communicate with their peers and others via technology.	"I communicate a lot more with my classmates. We talk about the homework and we share strategies. This never happened before, and it makes learning more fun." **(GA4)** "I spend more time on maths because I want to get full marks as I compete with my friends. We communicate more about homework, so I think it gives us more interest." **(BB2)**

RQ1 Do students interact more with WBH than with PBH?	IQ3 What are the main differences in the way you learn maths at home using Myimaths compared to PBH?	T2 Instant feedback	The data reviewed suggested that students felt the immediacy of the feedback was key to them interacting more positively with their homework tasks.	"I could revise and practice more math content on the website Myimaths because of immediate feedback. In each homework task, I wanted to get the highest mark of 100%. When my parents saw this, they were always impressed. This helped to motivate me to do more maths tasks on the computer." **(GB2)** "I could easily find out the answers to problems by using the 'Mark it' button. I would do this first and then try to work out the problems from the answers." **(BB5)** **Interviewer:** So, you used a trial and error type approach to solve the homework problems? "Yes. I clicked the Next button so that you wouldn't know my login details and how many times I attempted the homework task. This helped me to get very good scores not just in the homework, but in my end of year exams too. I practiced a lot." **(BB5)**

4.5.7 Student perceptions of Web-based and Paper-based homework– Summary Table 2

In Table 71, the theme instant feedback was perceived as being the key to students doing and completing more mathematics homework tasks. The word key is used to denote any change in behaviour that would stimulate their performance and develop learning benefits. Some students did state that they would check the "mark it" button to see the answer, work on mathematical processes independently or share procedures with friends in order to get full marks or the highest marks possible. Regardless, as to whether this is a trial and error type of approach, the effect of instantly available feedback seemed to have had a profound effect on student behaviour in terms of motivating them to continue working and achieving more.

Table 49. Summary Table 2-Student perceptions of Web-based and Paper-based homework

Research question (RQ)	Interview question (IQ)	Theme (T)	Meaning	Evidence
RQ1 Do students interact more with WBH than with PBH?	IQ4 The survey indicated that most students re-do or revisit their Online homework. Could you explain why?	T2 Instant feedback Sub-theme (marks)	The data reviewed suggested that students were keen to get full marks for their assigned task and that this encouraged collaboration or greater communication. Performance goals and mastery goals possibly set.	"My parents knew about the homework task and they can check my progress. They have even helped me as much as they could to make sure I got full marks." **(BA3)** "I wanted maximum score on all homework tasks. I would keep trying until I got the best score possible." **(GA3)** "I think all of us set out to get full marks as the homework on the computer was impressive. When we were told that it would support our continuous assessment mark, we all tried our best, of course." (**GB3)** **Interviewer:** Did you get full marks? "Not always. Sometimes, but my continuous assessment mark was very good. I was happy." **(GB3)**

4.5.8 Student perceptions of mathematics reflection and metacognition – Summary Table 3

In Table 72, students perceived that there were distinct differences between WBH and PBH. These differences made them feel that they were more confident in maths because of spending considerably more time practicing process skills and procedures. Their perception was that this facilitated and fostered better and more improved mathematics performance. Student perceptions were that WBH also encouraged more independent learning. Independent learning leads them to use additional resources such as help features, websites, their school notes, books, their peers, family members and their colleagues to support their learning process. Students felt that once feedback was given on answers that were incorrect on the WBH tool, they were far more inclined to spend time to correct their mistakes by finding out what they did that was procedurally wrong and get the correct answer. Besides, they felt that this helped make them better at mathematics.

Table 50. Summary Table 3- Student perceptions of mathematics reflection and metacognition

Research question (RQ)	Interview question (IQ)	Theme (T)	Meaning	Evidence
RQ2 What are student perceptions of their learning with WBH and PBH?	IQ7 Were you motivated in any way to do better in the post-test?	T3 Metacognition	The data reviewed suggested that students revised their thinking strategies in pursuit of full homework scores and as a result, were more inclined to reflect upon their solving strategies and the process skills used.	"We had the chance to reflect on what work we did in class recently. This helped us to improve at math and remember what we did. I think for sure the WBH made us practice and prepare for our tests a lot more. It also encouraged independent learning." **(GA1)** "Immediate feedback tells me to check my work or to change my thinking if I have the wrong answer. If I have the wrong answer with the PBH, I'm sure I wouldn't check it when given the paper back. I would just look at my mark." **(GA2)**
	IQ8 What is the better homework method PBH or WBH? IQ3 What are the main differences in the way you learn maths at home using WBH compared to PBH?			"Using the lesson notes to revise our thinking if we are wrong. With the PBH, you have to wait until the teacher marks it and this can take some time. Even with the corrections made, you can have forgotten the work that you did" **GB2** "There was more interaction with our classmates when doing the homework task. We would phone each other to check the processes used in order to get the answer correct. The communication helped with thinking. For example, after completing a question my friend told me how to check it without having to start the whole login process again. This way, you couldn't see how many times I completed the task. I think it's a good thing to be allowed multiple submissions." **(GA3 and GA6)**
RQ2	IQ3		Students regularly mentioned that they	"Being able to look at the lesson review to see how problems are worked out step by step is of great value. It is

What are student perceptions of their learning with WBH and PBH?	What are the main differences in the way you learn maths at home using WBH compared to PBH?	T3 Metacognition	would revise their thinking on their WBH task more so than on PBH in pursuit of the highest score possible.	as if you have a teacher that is helping you to work by yourself, sorry independently. PBH does not encourage this procs easily. I mean, it is more difficult to do." **(GA4)**

4.5.9 Student perceptions of mathematics engagement – Summary Table 4

Table 73 looks at the theme engagement. There is an interconnectedness between the themes of communication, instant feedback, engagement, and revised thinking (metacognition).

Table 51. Summary Table 4- Student perceptions of mathematics engagement

Research question (RQ)	Interview question (IQ)	Theme (T)	Meaning	Evidence
RQ2 What are student perceptions of their learning with WBH and PBH?	IQ2 If you can remember, what influenced the changes as to how you learnt with WBH since you started using it (you can discuss with peers)?	T2 Engagement Sub-theme (work)	The data reviewed suggested that students were engaged with their WBH in a manner of ways that were very different from their engagement with the PBH tasks. They worked harder and researched more mathematics material content.	"I look at my class notes a lot more and in addition, I used the help facilities on the website." **(BA4)** "Our parents can see our homework scores, and this makes me want to do better." **(BA3 and BA4)** "The biggest difference is the availability of feedback straight away. This tells us if we are right or wrong. If we are wrong, we can check the work and correct it. We can straight away go to our notes, or we can use the help feature." **(BB5)** "You can't just work on the computer; you have to work out the solutions on paper first before you enter any steps or give the answer. With 27 students in the class, the PBH takes the teacher a long time to mark. When the feedback comes, we have forgotten the math. This happened to me when I did the post-test." **(BB1)**
RQ2	IQ3	Engagement	Students regularly reported using help	"There was more interaction with our classmates when doing the homework task. We would phone each other to check the processes used in order to get the answer correct. The communication helped with thinking. For example, after completing a question, my friend told me how to

What are student perceptions of their learning with WBH and PBH?	What are the main differences in the way you learn maths at home using WBH compared to PBH?	Sub-theme (work)	features and mentioned interaction with their peers and other parties in order to attain correct answers to problems.	check it without having to start the whole login process again. This way, you couldn't see how many times I completed the task. I think it's a good thing to be allowed multiple submissions." **(GA3 and GA6)** "Instant feedback and the marked score was the key. My parents were very impressed with this, and that encouraged me to do more math homework. The GeoGebra homework was fun and enjoyable too. I understand graphs and their functions and transformations a lot more from GeoGebra. This is not the case for PBH." **(GA5)** "I found the language easier on the computer than on the paper. It took time to get used to, but once you understand how the website worked, it was a good benefit. It helps me to improve my math more than the work given to me on paper. You still have to use paper to solve problems before entering the answer." **(GA6)** "WBH gives you immediate feedback and allows us to change our thinking by looking at problems again. This helps us to practice more mathematics, which is a good thing. PBH is still good, but it doesn't encourage you to look at math in the way that WBH does." **(GA1)**

Research question (RQ)	Interview question (IQ)	Theme (T)	Meaning	Evidence
RQ1 Do students interact more with WBH than with PBH?	IQ2 What influenced the changes as to how you learnt with WBH since you started using it?	T1 Communication	The data reviewed suggested that students who access WBH tasks are more likely to communicate with their peers and others more than with PBH.	"I communicate a lot more with my classmates. We talk about the homework and we share strategies. This never happened before, and it makes learning more fun." **(GA4)** "I spend more time on maths because I want to get full marks as I compete with my friends. We communicate more about homework, so I think it gives us more interest." **(BB2)**

Student perceptions and linked supporting evidence suggest that they spent more time looking at their class and lesson notes for the WBH tasks. This perception could be due to any number of reasons. However, one possible compelling reason could be due to their parents having access to their results because they have access to their child's username and password. The perception was given that parental access to students' results seemed to motivate them to do better as student's BA3 and BA4 stated. Student GA3 also stated that she was encouraged to do more maths homework because she had impressed her parents with her homework scores. GeoGebra WBH was referred to as being "fun and enjoyable," whilst the perception of mathematics learning was taking place. This perception leads to the belief that key mathematical procedures were better understood with the use of GeoGebra WBH than with any PBH equivalent.

4.6 Summary

The results presented in this chapter indicate that the use of the WBH tools Myimaths and GeoGebra increase the amount of homework that the students complete, which in this study is indicative of interaction. The results suggest that the answer to RQ1 is that students did interact more with their WBH than with their PBH and completed more WBH tasks. This result is irrespective of tool usage. Homework completion rates were high regardless of the delivery method (WBH or PBH). Student perceptions regarding their homework interaction arose primarily from the provision of immediate feedback. This feedback was perceived to trigger more communication with their peers, family and household members and with additional tool features and other Web-based material such as YouTube, and GeoGebra Wiki. Study participants also perceived that they interacted more with support material to help them get the highest score possible. Students mentioned this added interaction with the GeoGebra homework tasks. This perceived interaction is consistent with the findings of Khanlarian (2010). The development or pursuit of performance-related goals to try to outscore your peers or achieve the highest grade possible was a motivating factor in this study. Moreover, it could be said that performance goals seem to have had a direct influence on the quantity and quality of the students' focus on learning, as suggested by Dowson & Mcinerney (2004).

Students also reported that WBH improved their homework scores and that this improved performance could be associated with an improved understanding of mathematics.

There are, of course, multiple benefits to be gained from the positive student interactions with mathematics WBH content, and improved homework scores were one of them. The results showed that there is a statistically significant difference between the two homework delivery methods and that WBH can be more effective than PBH given the context of the UAE and its reported lack of mathematics homework completion and low levels of self-efficacy. Also, WBH has several additional benefits that emerged from the measured constructs in the student survey and follow-up interviews. These benefits help to facilitate greater interaction, homework completion and improved mathematics homework performance. A more detailed discussion of the results is explored in Chapter 5.

Chapter 5 – Discussion, Conclusion and Recommendations

5.1 Introduction

This chapter aims to provide a summary of the reported results obtained from Chapter 4 and to discuss these results in relation to other studies. A compelling reason for using mathematics WBH is to increase students' engagement and involvement in the learning process, to improve their performance in mathematics, as measured by results taken from formal tests (Nguyen & Kulm, 2005). To enable students to have greater success with mathematics through an ability to rework problems again and again until the problem is correct increases their levels of self-efficacy (Locklear, 2013; Murray et al., 2006; Toker & Moseley, 2013). The purpose of this research study was to investigate the following:

a) whether students interact more with WBH than with PBH (comparative interaction effect – measured by homework completion)

b) student perceptions of their learning with WBH and PBH

By using the WBH tools Myimaths and GeoGebra versus traditional mathematics PBH, I considered if students became more engaged with WBH and whether their mathematics homework performance improved. Also, I considered student perceptions about the benefits of their learning with WBH and PBH as a result of tool usage. These perceptions were assessed via survey and follow-up interviews.

Education theorists are inclined to agree that homework can be a useful tool in building the student's mathematical understanding of the material taught by giving them the additional practice of the concepts and procedural applications involved (Cooper et al., 2006; Doorn et al., 2010; Gill & Schlossman, 2000; Marzano & Pickering, 2007; Omlin-Ruback, 2009). Web-based homework (WBH) studies have at least concluded that the delivery homework method used (WBH or PBH) does not diminish the benefits of mathematical procedural reinforcement through homework or additional out of class activities (Bonham et al., 2003; Hauk et al., 2015; Ncca, 2003; NCTM, 2008, 2014; Nguyen et al., 2006).

This chapter starts by discussing the answers to the research questions. The chapter then proposes what this study offers to the broader research community and the body of knowledge already accumulated on WBH versus PBH studies. This study takes into consideration the identified constructs that could affect homework completion and performance. In section 5.5, the study's limitations are presented in terms of its internal, external and construct validity and the study's overall reliability. Finally, recommendations for social change and for future research are proposed.

5.2 Discussion of Findings

There were two research questions (RQs) in this study that related to the possible effectiveness of WBH in comparison to that of traditional PBH. The first RQ enquired after the interaction effect, and it was pursued by an examination of the number of homework tasks that were completed and attempted. The simple rationale behind this methodical process was that if students attempted to do their set homework task (pre-test and post-test WBH and PBH), they were engaged in a process. If they were able to complete and submit the set task without duress, this could be considered a definite measure of homework interaction (completion).

The RQ was restated in the form of a null and alternate hypothesis, and the result was to reject the null hypothesis in favour of the alternate hypothesis that students do complete more WBH than PBH $H_1\ 1: p \neq p2$. Students were far more likely to complete their homework using the WBH tools Myimaths and GeoGebra as opposed to PBH. This result was evident from the post-test homework completion rates between the control and intervention groups. The availability of Online practice and multiple submissions seemed to entice students to interact more with their homework in the WBH group than in the PBH group. This behaviour is consistent with previous research studies (Bonham et al., 2003;

Hauk et al., 2015; Hirsch & Weibel, 2003; Locklear, 2013; Reis & Gulsecen, 2010; Zerr, 2007) and indicates that students are more engaged when completing WBH than PBH. Engagement in school can be defined as the degree to which students are intrinsically and extrinsically motivated to learn and perform well in a whole-school context (Welford, 1979). The definition includes the out-of-school context and the idea of supplementary work to reinforce the learning process that takes place inside the school.

One of the terms and variables used to measure a student's relationship with their school, according to Libbey (2004), is whether students care whether their homework is completed correctly. In the case of the UAE, it is if students care homework, is completed at all. This type of relationship is referred to as school bonding, and it means that the student has a commitment to the school that reflects an "investment in the group" which includes such constructs as commitment, attachment, involvement, school rules and engagement (Welford, 1979, p. 1; Libbey, 2004). It also pertains to the construct of homework itself and whether it is perceived or even proven to enhance learning. Even though the homework policy in UAE schools is to provide homework at least once a week to try to encourage a culture of bonding, responsibility and to promote and raise levels of self-efficacy, this rule is often not observed. Social connectedness has a strong influence on the level of student engagement with students having positive feelings of ability. These ability perceptions led students to be able to complete definitive tasks with a degree of competence in this study, and this is consistent with the findings in other studies (Doorn et al., 2010; Jones, 2008; Kats-Gold & Priel, 2009; Nguyen et al., 2006). Cultural traditions, and to some extent restrictions, that stem from an attitude towards the promotion of family life, social and religious bonding, can inhibit students from engaging in out of school curricular activities (Farah and Ridge, 2015). Mathematics homework is completed rarely in the UAE, and there are concerns about the self-efficacy levels of students and how they need to work more independently from their teacher and do the task (Sartawi et al., 2012).

This research has demonstrated that it is possible to engage students in mathematics homework and get them to complete it at a higher rate than traditional PBH. Using a different medium of delivery (WBH), students demonstrated their ability to socially connect, not only with the technology but reportedly from the student interviews with each other, in far greater ways than with the traditional homework delivery method (PBH). This finding is also consistent with earlier research findings (Hirsch and Weibel, 2003; Zerr, 2007; Hauk, Powers and Segalla, 2015; Wooten and Dillard-Eggers, 2016) but it was not discussed in those studies and related to interaction and self-efficacy. It is essential to mention that in this study, homework completion was high irrespective of the delivery method. This behaviour is out of line with the earlier claims that I and the supporting literature made about homework completion in the UAE (Innabi, 2009; Khanlarian, 2011; Al Khatib, 2012). This positive behaviour could have been a direct result of students being involved in the research process itself, which had some novelty effect. This novelty effect can be described as the 'Hawthorn effect' and will be discussed in this study's limitations section (see section 5.5). The positive behaviour, as mentioned earlier, could also be attributable to a student's attachment, connection and interest in the school, its rules and ethos, and cares whether homework is completed correctly (Libbey, 2004). Introjected regulation, where students' behave and perform well could also have played a contributory part towards their positive behaviour in order for others to respect them (Sartawi *et al.*, 2012).

Hirsch and Weibel (2003) found a positive correlation between the amount of homework completed and the number of correct solutions. This is indicative of students revisiting their homework questions multiple times until they got their problems correct. Hauk et al. (2004) found that WBH was completed at a significantly higher rate (78%) when compared with PBH (65%). However, when considering homework completion rates, we must be careful not to compare different case scenarios. Paper-based homework was completed, usually only once by students in this study in the pre-and post-test control groups. It was noted from interview conversations that very few students had the desire to re-do their PBH multiple times, due to the delayed nature of the feedback. Such a problem with feedback did not prevail in the case of WBH, as the feedback was instantaneous in the case of using Myimaths and prompt when students used GeoGebra. Web-based homework questions can be taken multiple times and practiced multiple times through help features, with only limited knowledge of the number of student attempts at similar questions. The only indication available to the teacher is whether the student resubmits the assigned homework task multiple times. In most of the research cases mentioned, it was hypothesised that the completion rate and the student's WBH score would improve. With this in mind, it would be a mistake to make rigid comparisons between WBH and PBH unless students in the WBH intervention group were given only one attempt to complete their homework. This asymmetry would work against the nature of the tools' facility and be impossible to police. It also defies the logic of using WBH, which is to engage the student in mathematical rigour and practice to improve the understanding of conceptual procedure (Khanlarian, 2011; Sartawi *et al.*, 2012; Hauk, Powers and Segalla, 2015). To combat the notion of inaccurate comparisons in this study, I considered the amount of homework that was completed as well as attempted.

The findings in this study showed that the majority of GeoGebra WBH group post-test mean scores were better than that of the PBH group, but the difference was not statistically significant. The student survey and follow-up interviews suggest that GeoGebra WBH provides students with the ability to learn geometric, algebraic and statistical concepts through construction visualisation. Also, as a result of their revised thinking, they were able to explore mathematical relationships more easily. Studies that supported this level of revised student thinking with the use of dynamic geometry software (DGS) to bolster both teacher and student special skills and mathematical development through visualisation include Guven and Kosa, (2008), Saha et al. (2010) and Masri et al. (2016). Students in these studies perceived that through using the tool features in their WBH effectively, they were able to visualise and promote their learning and their understanding of mathematical concepts and processes. This result was consistent with other research findings using DGS (Tat and Fook, 2005; Tarmizi *et al.*, 2010; Nathan and Scobell, 2012).

The construct of feedback in this study in comparison to that given in the literature is somewhat confusing. According to Hattie and Timperley, effective feedback given at the task, process and self-regulatory levels are all interrelated (Hattie & Timperley, 2007). They also concluded that feedback is more powerful when it addresses possible misconceptions or misunderstandings. They felt that this would help build the students' understanding of strategies and techniques that can be used to solve problems. Kulhavy (1977) found that for feedback to be beneficial to learning, the correct answer must not be easily attained. It was believed that students would merely copy the answer and would not look to devise suitable strategies to try to solve the problem. Therefore, this method was presumed not to lead to the promotion of learning (Kulhavy, 1977).

In this study, feedback was given at the very basic level in the form of a correct or incorrect answer. However, this type of feedback did not deter students from wanting to pursue the correct answer by reattempting questions in Myimaths or GeoGebra. Even though the correct answer was displayed, students wanted to gain a higher score and were prepared to repeat the entire homework as individual itemised questions were not part of the tool's facility. However, this is consistent with the findings of Walberg et al. (1985). They found that graded homework within a specified period had a significantly positive effect on student achievement and subsequently on their learning (Walberg, Paschal and Weinstein, 1985). With GeoGebra, the feedback was given on the construction as to whether it was correct or incorrect, but the correct answer was not shown. The students could have attained a graphical representation of an answer via help features (GeoGebra Tube or GeoGebra Wiki), but this would have required the student to have positive skill processes. These skill processes could have been communicated or acquired to attain a higher homework score. Students were awarded marks based on additional criteria.

In the case of the GeoGebra WBH, the answer to RQ1 was to retain the null hypothesis that students do not interact more with GeoGebra WBH than with PBH, $H_0\,1\colon p1 = p2$. This result was initially viewed as strange, given student feedback on their perceived levels of engagement with the homework activities. Student pre-and post-test homework scores were noticeably high irrespective of delivery method, and the mean scores for the PBH and WBH groups were close together. Interestingly, there was a statistically significant difference between the curriculum stranded homework tasks on shape and number and the other strands (algebra, measurement & data). This result could be due to the nature of the positive interaction with the GeoGebra WBH tool that led to high homework scores. It could also be indicative of the design of the WBH tasks and its PBH equivalent. Another critical fact to note is that the majority of the homework tasks that were set were on shape and number.

However, according to Santhanam et al. (2008), students' may have been involved in a self-regulatory process as a direct result of the positive feedback given to them by their teachers in the form of help and assistance and this could have contributed towards the high scores associated with the GeoGebra tool. Another contributory factor to the attainment of high scores is that if a student can see the work being done by their peers, YouTube or GeoGebra Wiki, they may develop the confidence to do it themselves. This type of interaction may get students' to reproduce or replicate the work with limited levels of understanding. Modelling is a practice that is associated with self-efficacy and can assist students' in developing proficiency and confidence (Bandura, 1978). However, modelling answers does not necessarily translate into an understanding of the conceptual procedures.

Learning the GeoGebra tool features, developing proficiency with the features, and using tools to construct objects was time-consuming and required a level of diligence and mathematical resilience that not all students in the GeoGebra intervention group could develop in the required timeframe. According to some mathematical educationalists, this process of building familiarity can take up to two years (Pimm and Johnston-Wilder, 2004). In this study, however, the timeframe was one 45-minute lesson in the computer lab. This limited-time allocation perhaps hindered the interaction effects between the students in the intervention group and the tool. Previous research studies have commented on the time students need to become familiar with the tool features of GeoGebra and other dynamic geometry software (DGS) as being crucial to its success (Tat and Fook, 2005; Preiner, 2008; Saha, Ayub and Tarmizi, 2010; Nathan and Scobell, 2012; Ravenscroft *et al.*, 2012; Thambi and Eu, 2013). It was noticed that in the earlier part of the study, homework completion in the intervention group using GeoGebra was far greater than it was towards the end. Student coursework and exams were a factor in preventing students from spending more time interacting with the software.

Several causal factors could contribute to heightening homework completion, and subsequently translated into improved mathematics homework performance scores. The first is that students are given paper-based material in class via coursework, exams and assessment for learning tests. This assessment type breeds a culture of familiarity with question style and format that relies solely upon students physically writing out their solution on paper. This procedure may have had a positive impact when students tried to interact with the Online material content and when students attempted to complete their WBH. Even though physically writing out their solutions in attempting to do their WBH would have been required at times, their developed familiarity with the tools and possible question style may have contributed to their improved performance. A second reason could be the amount of effort used with the WBH, regardless of the amount of time spent on WBH tasks. Some students were able to use the tools' assistance and help features to improve their WBH scores and consequently, developed the perception that their mathematics had improved. This finding agrees with those of Peng (2009). He found that students were not influenced by the tool used to learn accounting methods or principles, but were merely influenced by the ease with which they could answer questions correctly to get an improved score (Peng, 2009). Using WBH systems does encourage a trial-and-error type approach to problem-solving, which may not necessarily coincide with the students' perception of improved learning. With the GeoGebra WBH, this certainly could be the case in this study. Once students were able to get correct results via the correct tool usage and constructions, their homework was complete. However, their real understanding of what was completed may have been limited and merely instrumental. "Instrumental understanding" can be described as knowing the rules and procedures to perform set tasks without understanding why those rules or procedures work (Skemp, 2020). The completion of the assignment may thus have been contrary to their perceived understanding, as suggested in their follow-up interviews. However, as in other studies, students did suggest that they needed more time to build familiarity with the tool's feature, and the lack of time to satisfy this need could have had an adverse effect on their level of confidence, which could have contributed to insufficient learning taking place (Peng, 2009; Praveen and Leong, 2013; Mukiri, 2016). Arguably, with the availability of multiple submissions, problems that require key processes using algebraic manipulation are not fully understood by the students. Instead, what their work involves is a repetitive process of mimicking the steps taken in worked-out examples, help features or solutions to problems presented in the GeoGebra Wiki. With the GeoGebra homework, students said that they got the correct answer or construction by following the steps their peers used or what was presented in examples on YouTube or GeoGebra Wiki. Students were able to get maximum scores on their post-test GeoGebra WBH but may not have conceptually understood key mathematical processes.

It is important to mention that students who pursue high homework scores, are more inclined and led to believe that they are competent in that area of mathematics. This misperception may provide a false sense of confidence about their ability. If the students feel that the set homework task is merely work, to just try to get a maximum grade or the highest grade possible they may not be inclined to learn from their mistakes and rush through the work. This could have been the case with less challenging homework tasks that did not require students to use the multiple submission feature, as was reported in the Nguyen (2006) study, where students achieved very high homework scores without the need to resubmit the task. However, a counterargument against Nguyen's conclusion is that we have no way of knowing whether the students found a way to practice the homework task without the teacher's knowledge of unofficially practicing or reviewing the task before entering their login information. An example of this practice is given below during an interview in Boys School B.

> "The instant feedback helps you to check your work if there are mistakes, and you can resubmit to get a better mark. Many students involved in the study didn't like being limited to two submissions. There was an easy way around it." **(BB5)**
>
> – "What was that?" **Interviewer**

"Just click the next button without entering your login information. This way, you can do the task as many times as you like to make sure you understand what is required." **(BB5)**

This trial-and-error type approach to WBH was considered by Pascarella (2004) to be a serious limitation to students' learning. He felt that students would use the displayed correct answer to rework the problem and then attain the correct answer without having understood the mathematical procedures involved. However, later studies have focussed more on the student's interaction with the tool and have suggested that even if the student is using a trial-and-error type approach to learning, there are metacognitive skills that are being used. These skills are used when the student is in the process of revising their answer and perhaps their thinking (Tang and Titus, 2002; Jones, 2008; Khanlarian, 2011). These studies revealed that increased student interaction due to the immediacy of feedback led to an increased amount of time spent on reviewing mathematical content material irrespective of the student's knowledge base behind it. The fact that students were able to interact with their peers and other material resources in order to attain correct answers, improved their ability to learn both cooperatively and independently. This result is consistent with the findings of Laird & Kuh (2005). Through the availability of multiple homework submissions and the pursuit of the highest mark, trial-and-error increased student levels of collaboration, determination, and maybe even mathematical resilience. This behaviour may facilitate learning from one's mistakes, which could have helped to alleviate some elements of mathematics anxiety. Since mathematics anxiety was linked in the literature to low levels of student-self efficacy (see section 2.3.3), any alleviation of anxiety could improve levels of self-efficacy (Khanlarian, 2011; Means, Toyama, Murphy, Bakia, & Jones, 2009; Smith, 2009). Given that this study improved rates of homework completion and homework scores, it could be fair to say that the introduction of WBH had a positive effect on improving the levels associated with mathematics anxiety and self-efficacy. According to Hembree (1990), this could be due to the presentation of mathematics and mathematical tasks in a variety of ways in the classroom with suggestions as to how to follow-up at home for supportive learning and homework completion. The class teachers could make the lessons perhaps more stimulating and engaging, so students could more easily continue their work at home. Students in this study were frustrated by syntactical errors made that could have contributed to some form of numeric anxiety, as mentioned by Hembree (1990) and Ashcraft and Kirk (2001). Students in the interviews did comment that their teachers and peers were able to provide help and support when they encountered problems with mathematical procedures required by the tool, and with any issues associated with the tools' technical features. This type of supportive culture would help to alleviate forms of mathematics anxiety and promote efficacy (Ashcraft, 2002; Hembree, 2006).

Student perceptions about WBH in this study were very positive, as reflected in the survey results and the semi-structured interviews. Their perceptions of their interaction with the tools and whether it benefited mathematics learning was extremely positive. In this study, their perceived notions as to whether WBH improved their mathematics more so than that of PBH is warranted but questionable. The data suggests that there are perceived benefits that encourage the students to spend more time interacting with the homework material content and improve homework scores. However, it does not entirely support whether the additional time spent constitutes improved mathematical learning. As in other studies, there is evidence that WBH can offer "unique opportunities" to improve student learning and practices (Bonham et al., 2003; Hauk et al., 2015; Nguyen et al., 2006; Pascarella, 2004). For example, this study revealed student perceptions about the revision and review (revised thinking) of questions marked incorrect. This opens-up the relatively new area of metacognitive thought processes and skills associated with this behaviour. However, further research evidence is needed that supports student improvement with their final assessment results as opposed to just improved homework scores.

The fact that the results were statistically significant for all homework tasks on the post-test comparison of WBH versus PBH suggests that there are possibilities to explore when giving WBH to students to help improve their mathematics. The effect size ratio calculated for this study, suggests that there is a substantial difference between the students who were given WBH and those students who were given traditional based PBH. The intervention of WBH had the effect of significantly improving mathematics homework scores overall (irrespective of tool usage).

The results and scope of this study are unique in the sense that the homework activities covered multiple areas of mathematics that involved the four main curriculum strands in school (algebra, shape, number and data). The study attempted to look at two distinctly different types of WBH tools. The GeoGebra WBH was perceived by students as being extremely engaging and perceived by mathematics educationalists as constructionist in its approach to getting students to interact with technology in a way that is suitable for them to learn (Potter, 1996). This approach to learning mathematics using DGS is considered to be better by constructivists than other WBH tools, where students' input answers marked right or wrong, and the correct answer is displayed. However, we are not comparing WBH tools in this study; we are comparing WBH with PBH. This study has found that WBH goes beyond the result of equivalence (is at least as effective) as found in other studies with PBH (Bonham et al., 2003; Dufresne et al., 2002; Hauk et al., 2015; Hodge et al., 2009; Nguyen & Kulm, 2005).

The results from the survey and the interview are combined in this section to discuss the key findings from the study in relation to the literature and RQ2. In addition, these results will also be used to assess the internal and construct validity of the study.

The survey results and follow-up conversations with selected students indicated that students did not confront any problems with access to computers or slow modem speed. All the students could access the Internet, log on to a central Web server and access www.myimaths.com and www.classtell.com. Students said that with multiple submissions, they could develop a better understanding of how to complete some of the homework questions. Proponents of WBH say this approach is extremely advantageous, because it allows students, through repetition, to check and revise their work (Tang and Titus, 2002). However, as mentioned in Chapter 2, opponents to WBH claim that by allowing multiple homework submissions, you encourage a trial and error type approach to solving problems (Pascarella, 2004). This was the case for one student interviewed in this study, who reported simply entering numbers randomly until the correct answer was found. Multiple homework submissions can be controlled with some operating tools like WebAssign. WebAssign has a built-in facility that can control the number of homework submissions that is dependent on the type of question format. For example, if the question is of a multiple-choice format, the number of submissions would not exceed the number of distractors (Yee *et al.,* 2009). WebAssign will allow students to resubmit new or changed question parts, entire questions, or the entire homework task, however, the instructor has the final say on the number of submissions that are allowed (Tang and Titus, 2002). According to Zerr (2007), as long as process skills are being developed and the students are engaged in an attempt, re-attempt cycle that promotes the revision of mathematical procedures, there are many benefits students can gain from the availability of multiple homework submissions. Perry (2004) argued that students must be proactive in their approach to learning by finding out their strengths and weaknesses with the support of their teacher (Perry, 2004). Perry (2004) also argued that homework should receive appropriate feedback promptly so that students can understand the key processes of the concepts (Perry, 2004; Farrell, 2006). He said that once this is achieved, students can repeat particular processes in different contexts, be extended or moved on (Farrell, 2006). Perry (2004) and Farrell (2006) suggested that teachers should tell students that mathematics is a skill that needs constant development and that this development happens over time through the application of skill repetition. They also said that if a positive attitude is kept, self-efficacy in mathematics will increase and the knock-on effect will be to help reduce levels of mathematics anxiety (Perry, 2004; Farrell, 2006).

Students from the WBH group expressed their excitement towards the end of the study that "Doing maths on the computer was fun", "Maths on the computer gives more clues, more information and more practice", and "Doing maths on the computer made them understand certain topics better." These statements are consistent with the findings of both Nguyen (2005) and Demirci (2007).

A few students said that they did not like Myimaths because of the impersonal nature of the feedback given. They said that it was just marked right or wrong, and they felt that it could not show them where they had made mistakes. Myimaths is not an intelligent tutoring system, and it does not provide detailed feedback on ability or show students where they went wrong. Some students felt uncomfortable with this lack of feedback, as they lacked the confidence and ability to revise mathematical procedure independently. This lack of student confidence was mentioned in homework studies that looked at the role feedback played in assisting students to develop a degree of required resilience and motivation to continue to work and solve problems independently when they encountered difficulty (Feng et al., 2006; Hattie & Timperley, 2007; Johnston-Wilder & Lee, 2008).

It is difficult to interpret the neutral response in item E7, where 13 students remained neutral as to whether computer feedback helped them to recognise their mistakes. This result could be due to "task" level feedback, where questions are only marked right or wrong, and the student is required to "self-regulate", as described by Hattie and Timperley (2007). However, the availability of immediate feedback and scoring had the highest factor-extracted communality value, 0.892 (see Appendix 19). As such, it was the most important contributing factor in determining the responses to most of the surveyed statements E1–E25, and it was essential in determining what perception students had about WBH. Students said that they were able to revise their steps, learn from their errors and confirm concepts that had been previously studied in lessons. This self-regulatory process according to Zerr (2007) helps the student to build on previous knowledge and most importantly, how they can apply what they have learnt to other situations (Zerr, 2007)

From the survey results, all 204 pupils said they understood and in principle, agreed with the range of statement items E1–E7. Favourable agreements were with statement items E1 ("I like to do maths homework on the computer"), E2 ("Online maths homework motivates me to practice maths") and E3 ("I like to receive immediate scores on my WBH") of particular importance as they accounted for more than 72% of the total variance. These three statement items are the core reasons for the popularity of WBH, according to Bonham (2003), Dufrense et al. (2002), Nguyen (2005) and Demirci (2007). From the Nguyen (2005) study, this could have the effect of forming the student's perceptions and attitudes in a favourable manner that could lead the reader to form the opinion of research bias. In this study and Nguyen (2005), there was a minimal, neutral response rate where participants felt that they were indifferent about the statements and could not be forced either side, which is legitimate. There was less than a 10% neutral response rate in the survey, and this could be attributable to students who joined the study at different stages as a result of previous absenteeism. Students may have been unfamiliar with the WBH tools and its language. Apart from this, student responses to survey items E1–E7 suggested sound understanding of WBH as described by Bonham (2003). The survey statement E7 ("Online homework feedback helps me to recognise my mistakes") was statistically significant between groups (WBH and PBH). The group means were statistically significantly different ($p < .05$), and therefore we can reject Null Hypothesis, that the variance was the same or similar between the groups and accept the alternative hypothesis for statement item E7. In other words, there is a distinct difference between Online homework feedback (WBH) and PBH feedback, and this is due to the availability and facility of immediate feedback from the WBH tools.

5.3 Conclusion

The investigation of this study, WBH versus PBH in UAE Secondary Mathematics arrived at the following conclusions to its RQs:

RQ1. Do students interact more with WBH than with PBH?

This study found that students do complete more WBH than PBH. This positive homework interaction took the form of greater communication between peers, teacher and the use of additional resources that supported the teaching and learning process. As a result, homework completion was greater, and it can be reasonable to assume that the time spent on the interactive learning of mathematics was greater for the WBH group.

RQ2. What are student perceptions of their learning with WBH and PBH?

The construct of metacognition was introduced in the literature as an important part of this study (see section 2.3.8). It assesses how learners adjusted their thought patterns and mathematical problem-solving strategies to find the correct answer. In this study, according to the student interview responses, the change of thought processes was stimulated by the availability of immediate feedback from the WBH tools. Metacognition was mentioned in the literature review as being two-dimensional. Some students in this study used metacognitive knowledge and some metacognitive regulation. These dimensions helped them to overcome their mathematical errors and attain the correct answer, irrespective of whatever previous knowledge base they had. The prompt for this two-dimensional process to occur could have been a syntax error that was made, a procedural error, or students working from the answer. The follow-up student interviews suggested that they were able to develop or devise a strategy to combat their deficiency, whether it was through communicating with their peers, using help features or other mathematical resources such as school notes or the Internet. Metacognitive regulation took place immediately when the student realised their answer was incorrect. Students using WBH tools did not panic. They demonstrated that they were able to revise their thinking and the processes that they used to solve the problem. This process of revision is mostly lost when students complete PBH tasks because the feedback is not instant. Student perceptions, when interviewed, suggested that PBH tasks lost this metacognitive regulatory effect due to untimely feedback.

It appears from this study that most learners aimed to achieve the best mark possible, irrespective of what they knew or understood about their learning capabilities. It is unlikely that students in this study would know if they were tacit, aware, strategic, or reflective learners as described by Perkins (1998), or any combination of them all unless they had been informed or read material content that addressed this. However, it does seem that WBH does have the ability to encourage reflective learning, which helps the learner to think and reflect on the incorrect answer they got from the WBH tool used. This finding maybe true of the students who said that they tried to elicit the answers by the use of trial and error in the follow-up interviews. There is an argument for using the trial and error approach, however, that even when the student is engaged in this form of elicitation, cognitive thought and mathematical reflective analysis is still happening and can be considered a valid and useful form of learning (Suriyon, Inprasitha and Sangaroon, 2013). This evaluative process of the learning that has taken place or the procedural process used is a review of strategy and the student becomes more strategic about what it is they have done (Moore, 2002). According to Perkins (1998), this self-regulatory process that the student gets involved with promotes levels of self-efficacy and resilience. The student's level of newly found confidence is irrespective of the fact that they are working from the attainment of an incorrect answer. More than likely, without the student's knowledge, they have engaged themselves in all forms of metacognitive regulatory processes. They have engaged in the monitoring and control of cognitive thought processes as a direct result of immediate feedback and made conscious decisions as to how to correct their mistakes and attain better marks. These forms of human behaviour also involve social, emotional and motivational aspects of self-regulation in order for the student to achieve or pursue a homework score that they desire or find acceptable (Pasternak and Whitebread, 2014).

The self-regulatory monitoring process is triggered by immediate feedback in this study as in other studies on WBH versus PBH. Considerable evidence has been offered from the transcribed student-interview data that suggests that WBH does inspire actions that lead to "controlled processes" which change the cognitive behavioural patterns of the student, based on feedback that was given (Nelson, 1990). In this study, the action often taken by the student after feedback on their WBH was to resubmit. This behaviour is consistent with the findings of other WBH studies (Bonham et al., 2003; Dufresne et al., 2002; Hauk et al., 2015; Jones, 2008; Khanlarian, 2011; Mavrikis & Maciocia, 2003; Nguyen & Kulm, 2005). Such action would involve them going through the mathematical content material again and revising their thought processes and skills used (Nelson, 1990). According to Nelson and Narens (1990), this process allows students to manage their progress far better than by reliance upon the teacher's feedback. Students in this study expressed that, in the case of PBH tasks, feedback would often come at a time when they had either lost interest in the work that they had completed or had forgotten about it. Therefore, the implications of metacognitive practices in this research study with mathematics WBH makes a valid contribution to learning that exceeds the cognitive limitations that students experienced with mathematics PBH. This study has indicated the possibility that student perceptions regarding their mathematical learning with WBH are positive and can contribute to improved academic achievement. The positive perceptions about learning go across a range of ages, cognitive abilities, and learning domains and this is somewhat distinct from other research findings in other studies (Doorn et al.,2010; Nguyen & Kulm, 2005; Sommerville, 2015; Tang & Titus, 2002). The interconnectedness of the core generated themes in Chapter 4 (section 4.7.4) can be illustrated to show how the interaction with WBH can promote and foster additional mathematical learning and encourage a review of student thought processes and skills.

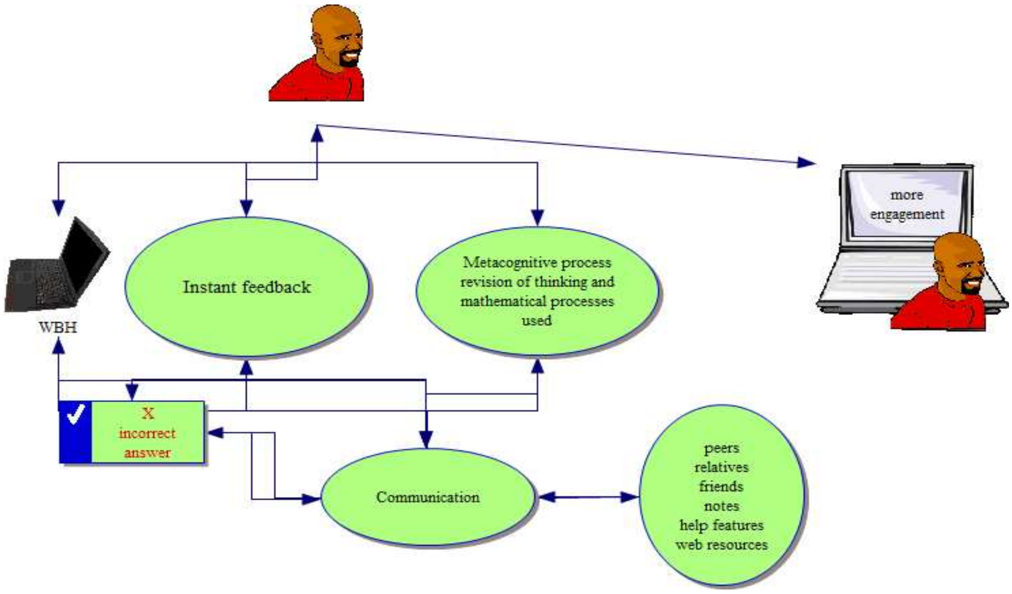


Figure 23. Displaying the relationship between themes.

Figure 23 illustrates the interconnected relationship between the themes that represent the results of the student interviews. Like other studies, this study presents the most influential component of WBH as the power of immediate feedback (Dufresne *et al.*, 2002; Bonham, Deardorff and Beichner, 2003; Mavrikis & Maciocia, 2003; Hauk and Segalla, 2005; Jones, 2008; Khanlarian, 2011). In figure 23, the illustration starts with the interaction with the technology and the WBH tool. From the feedback given, even in the form of the right or wrong answer, the metacognitive processes were triggered to encourage and revise mathematical processes. At this stage, communication can happen between the student and the tool with help features or additional Online resources, the teacher, class peers and others. Despite criticism of the correct or incorrect answer displayed as being poor and limited feedback given (Hattie & Timperley, 2007), mathematical thought process skills were triggered, and actions were taken by participating students to resolve problems. The learner tried to seek evidence to apply the strategy that would help them to learn. This process of reflection allows the learner to be extremely strategic about their thinking, and they can evaluate and reflect on any learning that has taken place (Moore, 2002). This reflective process led to improved mathematics homework performance and scores at a significant level. This area of the study is relatively new to the body of knowledge on WBH versus PBH studies as it promotes and fosters insight into how to get students to perform better mathematically.

We have no way of knowing how transferable metacognitive skills are with the thinking that is done, given the feedback for a particular type of question in mathematics. Both WBH tools Myimaths and GeoGebra did address some real-life application problems, and student perceptions did not suggest that they had trouble with the type of questions asked. However, there were help features and additional Internet resources available to the participants that could quickly have acted as prompts (YouTube and GeoGebra Wiki). According to research in mathematics metacognition, these prompts would have helped students to reflect on their strategies used for specific problems. These prompts act, without the student identifying that any metacognitive thought process or experienced difficulty had taken place (Kaune, 2006; Suriyon, Inprasitha and Sangaroon, 2013; Laistner, 2016). With the WBH, reflection happened as the learner was prompted, often through immediate feedback to re-do their work and to resubmit. This feedback led to more engagement with the mathematical content material. This study suggested that this increased engagement is as a result of students being motivated to improve their homework scores, and could lead to the review, revision and learning of mathematical procedures and content. This finding is consistent with that of other research findings on WBH (Dufresne *et al.*, 2002; Affouf and Walsh, 2006; Jones, 2008; Doorn, Janssen and O'Brien, 2010; Schneider and Artelt, 2010). This was the perception of students when asked whether they felt that they were better at maths as a result of their interactions with the WBH tools. Most of the students interviewed felt that PBH did not have the same impact on their learning of mathematics due to the untimely manner of the feedback and how it was given. Student perceptions in this study were similar, and in line with other studies that suggested, if feedback on PBH is not given on time, metacognitive thought processes are lost (Hattie & Timperley, 2007; Khanlarian, 2011; Laistner, 2016; Schneider & Artelt, 2010).

The tools used, and the student's homework environment was key in determining participatory levels and the homework scores in this study. Student objectives when using Myimaths were predetermined and controlled using the tool. Myimaths was successful in getting students to complete pre and post-tests WBH tasks. Students found the tool accessible and easy to use. Student experiences with the GeoGebra tool were positive, and arguably discovery-learning could have been achieved in some cases. However, the time it took the teacher and students to become familiar with the tool's operations made it difficult to use with what could be considered as an overloaded curriculum. In both situations, students were individually assessed, and if they had acquired a particular competence with the new or existing mathematical knowledge that had been set by the teacher or tool, they were happy about their performance. The tool, in this case, was at the centre of learning by providing the stimuli. The stimuli do not consider the social situation, cultural context, or the learners' needs, and this must be understood by the students' respective class teacher so that the tool usage and time are manipulated to suit desired learning objectives.

Section 1.1 described the pedagogical approach to learning that the UAE desires (constructivist). The UAE is recruiting staff who are supposed to be able to devise activities that challenge student assumptions; pose mathematical problems of relevance; build lessons around big ideas and assess learning in the context of daily teaching. This self-regulatory and reflective knowledge process in preparing the stimuli (WBH) is linked to the constructivist approach to learning. However, to adopt only the constructivist learning principles would be to deny or certainly undermine the social, cultural, religious, and political premise on which the UAE was built. Myimaths presents a body of knowledge to be learned, and even though this knowledge is in the form of considered facts, formulas, terminology, principles and theories; the didactic style of teaching (instructor-led) associated with this objectivist epistemology is not redundant. The teacher should be equipped with the course and core content to be learnt and most importantly, how that content information is disseminated. The information can be given in a variety of ways to suit the individual needs of each learner, and WBH tools can be used with the appropriate pedagogical approach to support this. Hence, it is not necessary to adopt only constructivist pedagogic principles.

5.4 Contribution to Knowledge

This study of WBH versus PBH with its cultural and religious constraints offers the research community robust information on students operating in a non-Western social setting. Rarely in education do we study students who have been introduced to the mathematical contributions of Muhammad Al-Khwarizmi for algebra, Muhammad Al-Karaji for mathematical induction and proof of the binomial theorem, Omar Khayyam for extracting higher-order roots, Nasir Al-Din Al-Tusi for his work on trigonometry and the Sine law, Abul Wafa Buzjani and Abu Nasr Mansur for plane trigonometry and the law of sines, Abul Hasan Al-Uqlidisi for using decimal numbers instead of fractions, Ibn Al-Haytham for Alhazen's problem, Ibrahim ibn Sinan's work on area, volume and circle theorems, Ibn Al-Banna Al-Marrakushi on computing square roots and continued fractions, Kamal Al-Din Al-Farisi whose application of conic sections solved optical problems and finally, Miriam Astrolabiya for her invention of the astronomical computer that is used to predict the position of the sun, moon, planet and stars (Abdeljaouad, 2006; Allen, 2007; Mastin, 2010). This historical account of mathematics contribution, we are not taught in Europe. Whether it be as a result of Arab nationalism or Islamic pride, it still serves a unique purpose when addressing theories of learning in the context of the UAE and beyond. Adopting only the constructivist approach to learning goes against the culture and tradition of this historical account that is taught and used to an extent by teachers and educational texts provided by the ADEC. The history associated with these scholars seems to combine both the behaviourist and constructivist approaches to learning, even though they would have been taught with pedagogical methods associated with the early Kuttub schools and Qur'anic teaching (Abdeljaouad, 2006). However, they were still able to construct, innovate and use educational thought for all to benefit from. It is encouraged by the ADEC that students are taught and made aware of their history and that this knowledge is used in teaching content material to support and motivate their learning in the fields of science, mathematics and engineering (ADEC, 2012).

The use of the tools Myimaths and GeoGebra for WBH tasks was also a unique feature in this study, as the two tools could be associated with different styles of teaching and learning theories. This was done deliberately to try to address an aspect of the dilemma of educational reform in the UAE. This dilemma addresses the adoption of constructivist teaching principles over those considered to be traditional. This dilemma is not just limited to the context of the UAE but extends to many other contexts worldwide. As a reminder, the GeoGebra tool was used to encourage and promote both the teacher's competence and the student's ability to learn by discovery. The Myimaths tool was used as it was considered to transfer information to the learner via direct instruction. Both tools had their distinct advantages and disadvantages (see section 3.6.2 – 3.6.4). This study draws attention to GeoGebra being a powerful discovery, teaching and learning tool as in other studies (Preiner, 2008; Schumacher *et al.*, 2008; Reis and Gulsecen, 2010; Saha, Ayub and Tarmizi, 2010; Briscoe, 2012; Kul, 2012; Praveen and Leong, 2013; Gergelitsov´a, 2014; Holan, 2014). In addition, this study highlights the possibility that constructivist thought that suggests the knowledge one discovers for oneself is truly learned could be taken beyond just the tool usage. Even though this study was not able to individually support the hypothesis that GeoGebra WBH tasks improve mathematics homework performance scores, it was able to draw on positive statement item comments from the student survey and interviews. There is also the distinct possibility that it supported students in this study to perform better on answering homework questions on shape than the other curriculum stranded areas.

There is little challenge to the notion that learning is a discovery. However, the traditionalist argument that information given via direct instruction is necessary and important has some value and cannot be ignored in this research process and context. Constructivism can lead to students not knowing what they had found or supposed to have discovered, which would raise problems when they had to apply what they had found in real-world situations. Without help and support from their class teacher or peer, this may lead the student to discover and taking ownership of the incorrect answer. Also, by working collaboratively or in groups, as is encouraged in constructivist teaching principles, some students were more able to make discoveries of which other students learnt, by subsequently copying the work (Bandura, 1978; Garelick, 2011). Some of this discussion is related to what was found in this study because there were students who mentioned communicating with others to attain procedures that would lead to answers. There is only the assumption that students are benefiting from the repetition of procedural methods and practice as a result of an attempt, re-attempt cycle when answering mathematics homework questions. However, if students were merely trying to get the correct answer by copying a procedure, they may not be able to apply what they have learnt to different situations.

This research showed that students involved in the study process demonstrated competent levels of self-efficacy for the most part when completing their assigned homework tasks, as homework completion rates for WBH (pre-and post-test) tasks were high. This level of self-efficacy must be noted, given research evidence that suggested UAE students have reportedly low levels of self-efficacy and rates of homework completion (Innabi, 2009; Khanlarian, 2011; Al Khatib, 2012). According to Bembenutty (2011),"To be successful in homework completion, learners need to be self-regulated by setting homework goals, selecting appropriate learning strategies, maintaining motivation, monitoring progress, and evaluating homework outcomes." This he relates to the self-efficacy levels of the students as well as "goal setting, time management, managing the environment, and maintaining attention" (Bembenutty, 2011, p. 449).

Beyond the context of this study, both tools that were used by the participants yielded positive outcomes for mathematics education practitioners to consider. In this study, it was clear that the teacher and students needed more time with GeoGebra to familiarise themselves with how the tool could operate more effectively for them. Myimaths might be considered to be a less powerful tool, as it is effectively an Online textbook. However, it was easily accessible and more rigorously used to support and supplement the teaching and learning in this study across a greater range of the curriculum content. Students were able to access the information and use the tool to their desired effect in a shorter space of time than was the case with the GeoGebra tool.

Both Myimaths and the GeoGebra tools used in this study created conditions for students to be given clear goals and receive near-immediate feedback about their progress. This feedback was, in many cases, an affirmation as to how their mathematical process skills were developed and used, irrespective of students being given the answer marked right or wrong, which is considered limited feedback.

Students expressed thought processes and skills that they were using to complete set homework tasks aligned and associated with self-regulatory techniques that have been found to improve learning (Schneider and Artelt, 2010; Laistner, 2016). The ability to control thoughts and behaviour before, during and after a set task is considered to be a key ingredient in the development of metacognition. The students interviewed in this study demonstrated that they were involved in mathematical metacognitive thought processes by identifying and relating to whether the task that they were about to embark on was like any previous task that they completed in class. This self-regulatory review process is said to help the student identify what they want to achieve and what they need to do first in order to achieve their desire to perform well on the set task. During the tasks, students would use the feedback from the tool to decide whether they were on the right track and, if not, ask or find help through various communicative methods. If they were wrong with their answers and they wanted to re-attempt their WBH task, they could, and this encouraged more metacognitive thought processes as to what they could do differently. This behaviour is consistent with the finding from Zerr (2007). Zerr found that students who were engaged in the attempt, re-attempt cycle were able to build on previous knowledge as some homework tasks built on previous learning so that the first task was a pre-requisite to the second (Zerr, 2007). The study found that students were able to review and reflect upon their answers in terms of what worked well and what they could have done better, and most importantly, how they could apply what they have learnt to other situations. The situation of identifying reflection as a metacognitive thought process is, to my knowledge, relatively new when comparing WBH with PBH studies. However, the attempt, re-attempt cycle that students were engaged in, that possibly triggered reflection, is consistent with other studies (Tang and Titus, 2002; Jones, 2008; Doorn, Janssen and O'Brien, 2010; Schmitz and Perels, 2011; Suriyon, Inprasitha and Sangaroon, 2013).

Many studies on WBH versus PBH have highlighted the importance, benefits and power of immediate feedback (Bonham et al., 2003; Dufresne et al., 2002; Hauk et al., 2015; Jones, 2008; Khanlarian, 2011; Mavrikis & Maciocia, 2003; Nguyen et al., 2006; Pascarella, 2004). However, few studies have focussed on addressing the metacognitive thought processes involved when students can revise their thinking and resubmit their work multiple times to increase their score for a higher award. It is known that metacognitive strategies are more effective when students are able to work collaboratively together so that they can support each other and make their thinking more explicit through open discussion (Laistner, 2016).

This study's important contribution to the broader body of knowledge is to highlight what students said after they were given immediate feedback. The revised thinking the students mentioned is an area that should be devoted to further research and investigation. The potential impact of this approach is high. It could be achieved in practice if students can take greater responsibility for their learning and develop an understanding of what is required to succeed (Sommerville, 2015).

This study also highlights that teachers have a responsibility to promote the positive use of technology in the classroom and at home. More significant technology usage is supported by the evidence of improved homework performance scores. How effectively this can be done depends on the amount of professional development and training the teacher receives in trying to use selected tools to support and supplement the teaching and learning of mathematics. Training should be an on-going process, as changes in technology that support mathematics teaching in secondary schools are also on-going. It can take teachers two years to become familiar with the use of a tool and how it can effectively support and supplement mathematics teaching and learning (Pimm and Johnston-Wilder, 2004).

5.5 Limitations

The limitations of this study are the characteristics of the design and methodology that could influence the interpretation of my research findings. They are the constraints that will act on the study's generalisability. In this section, I will try to address the study design in terms of its reliability and the methods that I used to establish internal, external and construct validity.

5.5.1 Internal Validity

Internal validity addresses whether there can be a connection or relationship between variables (independent and dependent) and how well an experiment accounts for potentially confounding variables (Hartas, 2010). These independent variable factors can occur at the same time. Variables such as student maturation, testing style preferences, instrumentation, regression towards the mean score, selection of subjects based on extreme scores, experimental mortality and any interaction of these threats could have an overall effect on the validity of the study. There are possible threats to the internal validity of this study. As stated in Section 3.3, a two-group control pre-test, post-test research design of a study is criticised for its problems with internal validity. The design assumes group equivalence from the pre-test, and no one is sure what measurable impact of taking the first test has on the second

(Dimitrov and Rumrill, 2003; Cresswell, Ivankova and Stick, 2006). Even though students were randomly assigned into test groups to try to make them equivalent from within their selected schools, a random selection of the schools did not take place. This limits the generalisability of the results to a larger population. Generalisability rests on the notion that transferability of the research findings can take place. For example, from this research teachers could find elements of this study that may support their practice. Also, how large and varied the sample population can determine how important any form of inter-relationship there is between generalisability and transformation. Therefore, any conclusions drawn about causality have less chance of being definitive.

Some students in the PBH interviews said that they were initially disappointed when they found out they were assigned to the PBH group. These students expressed a distinct lack of interest in performing better on the post-test PBH task, especially when they felt that they had done enough the first time. They had achieved the highest mark possible or at the very least, a mark that was considered to be acceptable. In the student interviews, they mentioned that some in the PBH group completed WBH to check if they did the right thing on specific questions. This behaviour could have been further encouraged by the close resemblance of some WBH and PBH tasks, especially with the GeoGebra tool. Students would have been able to communicate and see visual representations of their peers work and perhaps use their informed understanding to complete their PBH. This behaviour could be associated with the possibility of cross-contamination and was considered in the analysis of student results, especially where high marks (ceiling effects) were achieved.

Maturation is not usually associated as a threat to the two-group control design process (Cohen et al., 2007; Hartas, 2010). However, this lack of association is based on the assumption that the participants in both groups matured in their understanding of the experimental tools used for their WBH (Myimaths and GeoGebra), as well as the tasks used for their PBH at a similar rate in terms of how to do and complete their homework process. In this research, this was not the case as students changed their behaviour towards homework completion over the course of the study. This change of behaviour was noticed when students in the PBH group were more inclined to drop out of the post-test due to lack of interest, fatigue, or the feeling they had done enough on the pre-test. This was certainly the case with students who got full marks or nearly full marks on their assigned homework tasks, especially in the PBH group. Besides, it was also possible that the selection of some participants in the intervention WBH groups consisted of high-ability students in comparison to the control PBH groups. This could account for the larger mean score differences between the two homework groups in the pre-test that led to the result being statistically significant in favour of PBH. An unintentional sampling bias could have happened during the selection process that unknowingly assigned high ability students to the control group. I would have no way of knowing unless I was to look at student names and their working at ability levels, but since participating students were promised anonymity, it would not be ethically sound to do so.

With the instrumentation, the administering of the different homework tasks and the marking of the GeoGebra WBH by the different class teachers could have impacted the results. This impact would have started from when the lessons for the respective homework activities were taught and what information was given to the students by the class teacher about the WBH and PBH tasks that were set. Besides, I have no way of knowing how much help and support were given to students by their respective class teachers before and during the time in which the pre-test and the post-test were given. This would undoubtedly be true in the case of the GeoGebra WBH, where teachers were given a rubric to use to mark student work and to provide feedback (see Tables 15 & 16). This behaviour could have had a confounding effect on the results attained, especially with regard to the ceiling effects that were experienced with the GeoGebra WBH tasks.

The sample size used in this study could be considered large, and therefore there is an increased chance of finding significant differences (Cohen et al., 2007; Lenth, 2007). A larger sample more reliably reflects the population mean. The research design required a population size of 316 pupils after conducting a power calculation. However, approximately 540 students were involved in the pre-and post-test WBH versus PBH study (see section 3.5). Ethical considerations in trying to involve as many students as possible within each school could have had an impact on the results of this study.

Considering, I had restricted access to female schools and was reliant upon the integrity and good nature of the class teacher to provide me with accurate data that could be taken in good faith must be considered as a limitation. However, this situation has happened in other WBH versus PBH studies where the researcher is dependent on others to gather data and to provide the researcher with accurate information (Dufresne et al., 2002; Hodge et al., 2009; Jones, 2008). In all cases, they reported that the data was gathered and collected in good faith but was highlighted as a limitation as the teacher would be unlikely to present themselves as being a poor representative for the institution in which they worked.

Concerning experimental mortality, the differential loss of participants across groups was small. Some participants were not involved or chose not to be involved in the post-test for various reasons. Absenteeism was noticed more with the control PBH group. In the follow-up interviews, students were asked why re-doing specific PBH tasks marked incorrect with the teachers' feedback was unpopular. Their responses suggested that they were put off by the time it took to get the feedback and that the slow feedback made them less inclined to want to make corrections. Some students said that they were more than happy with their first mark given and were not motivated to do the post-test task for a higher award. Again, they perceived that the timeframe was too long for feedback in comparison to WBH set tasks. This form of "resentful demoralisation" (Michael, 2004, p. 11), where students perceive that treatment in one group is less desirable than the treatment in the other could impact on the student's ability to perform at an appropriate level. This finding did seem to be the case in this study after follow-up student interviews suggested that some students opted out of doing their PBH task because they perceived the benefits to be far less than the WBH group.

The fact that students chose to re-do their homework multiple times in order to improve their mark could be considered a critical feature of WBH use and a source of benefit to learning. Design contamination was another possible threat to the validity of the study. This contamination occurred when students in the control group felt that those in the treatment group were better off and, as a result, control-group students would not make a concerted effort to participate in the PBH tasks. This perception could adversely affect the attitude of the participants in the control group, especially when doing the post-test, as it would be a repetition of something that they had already done. This attitudinal change could have affected the mortality rate of the control group, as students may have felt inclined to drop out.

Syntax errors were a common problem with Myimaths, as students may have attained the correct answers in their calculations, but due to an input error, nevertheless have the question marked incorrect. This problem was highlighted in the Wooten & Dillard-Eggars (2016) study. Students in this study also expressed dissatisfaction with their effort to answer questions completely with the correct calculations throughout a process, but when entering the answer, a syntax error was made, and this gave them a lower score. This ability of syntactical errors to interfere caused much frustration and possible anxiety as it encouraged most students to repeat the whole process and correct their answers, even though the numbers would have been slightly different. Trying to prevent students from doing this throughout the study proved futile, as they would simply click the "next" button and take the homework task anonymously, to make sure they got procedures and input functions correct before completing the actual WBH activity.

It takes time to get used to GeoGebra. The tool features need to be experimented with and played with before students can begin to feel comfortable with using slide features and animation. Papert (1996, pp. 2–7) uses the word "thingness" instead of the academic word "reification". He describes a method of pointing, clicking, dragging and pulling down menus to help a created object become almost lifelike by moving. However, in creating the snowman, the "object" was created using a variety of different methods, such as pointing, clicking, dragging and pulling down menus. Students had to take a great deal of care in getting their points placed correctly. Once students finished the snowman, some started to explore the additional drop-down menu features, such as the slide and angle icons. Students were given a worksheet with instructions to make the object, but they were not required to bring the object to life by making it move around. For this reason, a GeoGebra applet was created for them to use (see Figure 6 and 7). It would have been ideal to have scheduled more time in the computer labs to help students to be more creative in this way. The power of

GeoGebra lies in its ability to make objects move but considering the time it takes to be able to master the software, this was not possible in two 45-minute lessons. It can take a good three years for a teacher to train to use technology well. One year to become personally familiar with tool features, another year to work with the new device or software in a classroom setting and a third-year to reflect on the successes and learn from failures (Pimm and Johnston-Wilder, 2004).

The GeoGebra homework tasks were peer-and teacher-assessed using an adaptive approach to the rubrics from the skills development curriculum, taken from the ADSM and given levels of emerging (E), developing (D) or mastery (M). This subjective approach to evaluating student work could lead to controversy and a lack of consistency as the curriculum rubrics were applied across the four schools with different teachers. Problems arose with the teacher's interpretations of the rubrics and how students interacted with the tool and their final production of work. These problems appeared in the context of how students experienced the tool and its features, as well as their own capabilities. Questions indeed arose when considering the quality and equity of the teacher assessment on the GeoGebra WBH (Morgan and Watson, 2002). In order to combat these hazards, teachers were given a rubric to support a somewhat standardised approach to the marking (Ravenscroft *et al.*, 2012). Given that the teacher's subjective evaluation of the criteria could undoubtedly lead to ambiguity, the rubric would give some insight into how the evaluation came about (see Tables 3 & 4). Later this process was moderated to see where specific disparities occurred.

5.5.2 External Validity

The four schools chosen in the emirate of Abu Dhabi may not necessarily be a true reflection of the Emirate population. There are arguably socio-economic, demographic and cultural differences in each of the seven Emirates that cannot possibly be fairly represented by the two girls' and two boys' schools chosen. Given the cultural differences and attitudes towards family life and religion in the UAE compared to elsewhere (in particular Western countries), it is also difficult to assess how this sample of students and their results could be applied rigorously to other settings. The UAE context certainly has its positives when evaluating the use of WBH tools to complete maths homework in a second language, from both an Arabic and English foreign language perspective. Students did indicate from the survey and in follow-up interviews that they did not experience language problems when completing their mathematics WBH. It could also be that students involved in the study had positive experiences with the homework tools that encouraged greater homework completion and improved homework scores. These findings could be applied to many kinds of people, even those not represented in the sample. This enhances the external validity of the study as generalising across populations can occur when particular research findings can apply to many different kinds of people irrespective of their social, cultural, demographic and political backgrounds (Hartas, 2010).

There is the threat of multiple treatment interference in this study, as students were randomly selected to be in either the control or intervention groups. Some students would have had the experience of both PBH (control) and WBH (intervention) groups. It is, therefore, possible that the effect observed, is present only when people are exposed to this intervention or treatment. In the real world, one would not observe the same effects of an intervention if not exposed by other forms of intervention or treatment. Some students in this study had the experience of being in the PBH and the two types of WBH groups (Myimaths and GeoGebra). In a drug experiment, if the same animal were given three different drug doses in some sequence, the effects of the second and third could not be separated or distinct from the delayed effects of the previous doses (Michael, 2004). We cannot be sure how the possible effects of the second, third or possibly fourth dose of WBH and PBH had on some students over the study duration.

Also, we have no way of knowing whether the process of pre-testing could have influenced the results because there is no baseline measurement against groups that remained completely untreated. For example, students who are given a pre-test maybe inclined to try harder with their homework activity, and both the WBH and PBH groups would outperform students who were not given a pre-test. This behaviour makes it difficult to generalise the results to encompass all students.

Another problem is that it is impossible and unethical to isolate all the study participants completely. If two groups of students attend the same school, it is reasonable to assume that they mix outside of lessons and share ideas and thought processes as well as skills. This behaviour could potentially contaminate the results. In order to try to combat this effect, students were drawn from other schools in this study, but this gives rise to the notion of selection bias as randomisation is not possible.

5.5.3 Construct Validity

Construct validity is concerned with the degree to which a test measures what it claims to be trying to measure (Hartas, 2010). It is conceivable that the constructs used in this study are not exhaustive and do not accurately represent the variables, and perhaps more importantly, the extraneous variables that could exist in real-world condition settings. Therefore, only an interpretation is given as to the possible outcomes of this study, and the generalisability of results faces further difficulty in this sense (Shadish, Cook, & Campbell, 2005).

This study used two WBH tools (Myimaths and GeoGebra), and I felt that Myimaths was operationally easier to use and more appropriate than GeoGebra. Far more homework tasks were completed using Myimaths than using GeoGebra. This was due to ease, accessibility and time in relation to the curriculum content being covered. However, it could be argued that the homework studies do not capture the full breadth of the construct being measured concerning mathematics homework and whether WBH is a more suitable method of delivery than PBH. It could be because the full breadth of WBH has not been explored.

Some students may not have participated passively in the research project, and as a result, were involved unknowingly in hypothesis guessing. This is where they were thinking about what the project was about and basing their behaviour on what they had guessed. It was clear to some students that the key dependent-variable, homework score, was being measured by the independent variables of PBH and WBH.

Many students are anxious about being evaluated and interviewed. If their apprehension makes them perform poorly, it is difficult to suggest that it is part of a treatment effect. Some other forms of evaluation apprehension also include the human tendency to want to look and to perform well. If the student desires to look good and to perform better by achieving full marks, it could be wrong to label this as a treatment effect. It could be considered that the apprehension has become confounded with the treatment, and we would have to be careful as to how we interpret the results. Surveyed students indicated that due to greater communication with their peers, parents and other sources with the WBH, they were far more inclined to compete for maximum marks to impress interested parties. Introjected regulation, as a reminder from the review of the literature, has the effect of making the student behave well in order for others to respect them, and this can assist student performance and help to avoid considered forms of inappropriate behaviour and possible shame (Sartawi et al., 2012). The behaviour could also indicate why it was possible that participants were more motivated in the WBH post-test. Another reason for motivation could be because of the researcher. The break from their regular class teacher may have refreshed some attitudes towards learning, and this was evident in other WBH studies (Donovan, Bransford, & Pellegrino, 2010; Dufresne et al., 2002; Nguyen & Kulm, 2005). Also, students may have artificially detected a lack of neutrality in my belief about the outcome of PBH, which could have affected their performance (Hartas, 2010).

5.5.4 Reliability

Reliability refers to the consistency or stability of something that is being measured, and it is considered high if the measured result is repeatable (Hartas, 2010). The repeatable measures can be achieved by offering some details on the measured constructs and the processes used to collect and analyse the data in this study. The consistency of the measured constructs is examined in terms of its stability (consistency over time), equivalence and internal consistency. Consistency over time is the degree to which a measurement under the same conditions is the same each time it is applied to the same participants. In this study, a test and retest (pre-test, post-test) took place as a measure of reliability on the same participants at two different points in time. The timeframe of a week was used and is considered to be an acceptable interval (Muijs, 2012). The reliability of equivalence refers to how well the two administrative tests were carried out (WBH and PBH pre-test, post-test) and whether we can agree with the measurements attained. Finally, internal consistency refers to whether all items in an identified construct measure the same thing (Muijs, 2012).

From the pre-test, post-test WBH and PBH tasks, a missing value analysis was conducted. Little's missing value analysis (MCR- missing completely at random) test did indicate that the null hypothesis should be retained as the values were not missing completely at random. The test did come up with a statistically significant result which could question the reliability of equivalence between the pre-and post-test measures. However, since missing values accounted for 15 out of a possible 541 cases (2.7%) in the control post-tests and 7 out of a possible 536 (1.3%) cases in the intervention groups, a decision was made to ignore the missing data, as it was less than 3% for the control and 2% for the intervention groups (Muijs, 2012). Since sample sizes were large, this amount of missing data would have little impact on the overall results of the project. Some justification has already been provided with the follow-up student interviews that suggested students were put off by having to complete the same PBH task a second time when they felt that they had already done enough. They also said that the feedback came long after they had completed the task, and at times they had forgotten the material content. The student responses to the interview question, "Why was the post-test PBH unpopular to complete?" can confirm that the missing data was not missing by random chance and that the students had compelling reasons to leave the research process.

The impact of multiple homework submissions is unknown, as only one homework score is recorded. That homework score was the highest score achieved by the student. The tools would indicate only the number of attempts the student had to complete the task.

Cronbach's alpha and factor analysis were used to measure the internal consistency of the survey items E1–E25. The α coefficient indicated that the survey design was a reliable measure for the RQ of student perceptions about WBH in comparison to that of PBH. The alpha coefficient results suggested that the internal consistency and reliability of the constructs being measured in the student survey were suitable measures to help answer the RQ. The tests suggested that the same underlying construct of student perceptions were being measured. In theory, the closer α is to 1, the greater the reliability (Hartas, 2010). The factor analysis did suggest that some survey statement items were perhaps better suited with others to measure similar constructs as some complex variables loaded on more than one component factor;—however, this is a subjective point. The results supported the notion that the constructs were measuring what it was supposed to.

The cultural aspect of students not wanting to tarnish or say anything detrimental to school leadership, and the efforts of their country must be considered. Interviews can be intimidating, and we have no way of knowing what impact or relationship each participating student had with their respective class teacher or their peers. If students perceived the research study as being innovative and drew conclusions about the study that supported this, it would have impacted their responses to the interview questions (May, 2012).

It is difficult to know whether mathematical learning is taking place if I am not associating PBH and WBH scores with final test scores, as in the case of the Bonham (2003) and Hauk and Segella (2005) studies that took place over a much more extended period. This study design did not answer the RQ about whether homework scores could improve via the use of the tools Myimaths and GeoGebra in comparison to that of traditional PBH given. 'Learning' is much harder to define and might be worth pursuing with a different study design that could measure learning gains.

5.6 Recommendations for Social Change

The key advantage of WBH identified by this research is the immediate feedback given for both correct and incorrect answers. The feedback helped students in this study and others to identify and correct thought processes before they could become habitual. In addition, WBH allowed and mostly facilitated the process for students to work on their assigned homework task problems several times, due to the availability of multiple submissions. The availability of multiple homework submissions encouraged additional mathematical practice that could provide students with a better understanding of the mathematical process skills involved and the solutions that they attained. Student perceptions in this study suggested that they were intrinsically motivated to pursue high scores because they were allowed to re-do and resubmit their homework tasks if they had made procedural, syntactical or computational errors. It also allowed them to review the content material through help features, Internet resources, lesson notes and various other forms of communication that may have involved their peers, family members and friends. The benefits derived from this Web of social interaction could have positive and lasting effects on developing mathematical content knowledge; therefore, WBH ought to be given and encouraged. It is not recommended that WBH replace PBH because students need to be able to write out and methodically structure their thinking and solutions. Students, when interviewed, did identify the need to be able to work out their solutions to problems given to them by the WBH tool on paper before they entered their answers.

Several key advantages are evident for both teachers and students if WBH is given. The first is that it would save considerable time in the marking of student homework and is the reduction of time spent reviewing homework questions in class, as a result of the help features, Web resources and other communicative means available to some students. However, PBH or topic tests would still need to be given to make sure that students' mathematical skills, procedures and layout meet teachers' expectations as to what is being taught and learnt. Several studies have indicated that mathematics teaching staff were able to focus more on how they structured their teaching and learning in class after the implementation of mathematics WBH and that this is considered to be a definite form of teacher reflection (Bonham et al., 2003; Dufresne et al., 2002; Potter & Johnston, 2006; Wooten & Dillard-Eggers, 2016).

The benefits to the students must somehow manifest in improved mathematical performance, progress and attainment. At present, there is not enough conclusive evidence to support that student progress and attainment has improved because of WBH practices. There needs to be more time and research spent on investigating WBH and any causal effects that it may have on improved mathematical performance and exam scores.

In order to try and reduce the Hawthorne effect, it is recommended that mathematics WBH be an integral part of any continual assessment procedure that involves the submission of set homework tasks. Even though the Hawthorn effect is a problem associated with research design rather than for teaching and learning, the setting of the research process can automatically trigger the effect (Hartas, 2010). How this is negotiated is entirely up to how schools and their mathematics departments view their policy on homework and mathematics homework delivery methods and completion. Mathematics WBH used effectively with PBH could help teachers identify student problems more quickly than with the reliance on PBH and tests. Web-based homework could also be used as a measure of student support that helps to foster and build competency, confidence and greater mathematical social justice. Through immediate feedback, WBH offers greater social justice than with relying solely on the teacher. The tool is indiscriminate when giving feedback to students, and irrespective of the type of feedback given, it is the same that is given to all. Students cannot complain about or compare feedback that has been given to other students with their feedback. They are also less inclined to discuss issues of favouritism that could potentially reduce motivation in some students and make them less inclined to be part of any homework process or culture (Bennett and Kalish, 2006; Dillard-Eggers *et al.*, 2008).

Finally, the mathematics teacher's ability to effectively use technology must be improved, and on-going improvement must be part of their professional development. Working with the teachers in this study indicated that there is a need to support teachers with this process. Improved technology usage will enable teachers to better tailor the curriculum content and pedagogical approaches to learning that could better suit the needs of all learners. This professional development is crucial for the success of any tool used to support the teaching and learning of mathematics (Strauss, 1993; Pimm and Johnston-Wilder, 2004; Almekhlafi and Almeqdadi, 2010). It is vital that the teacher can instil confidence in their students when it comes to using technology to support measurable improvement in mathematics, and this can take time. Instilling technological confidence would mean that mathematics teachers need to use a WBH tool regularly to support classroom and lab (ICT) instruction as well as to encourage the use of that resource outside the context of school on mobile applications or at home. Also, it would help encourage students to become more independent and responsible for mathematics lessons; an outcome that would be positively welcomed.

5.7 Recommendations for Future Research

This study may provide a framework for further study. First, to replicate this study would be beneficial, with a longer duration, so that the study was tied to student attainment and exam performance. The cultural context of students who participated in this study was different from that of most studies on WBH versus PBH, as there were reported low levels of self-efficacy and rates of homework completion (Innabi, 2009; Al Khatib, 2012; Sartawi *et al.*, 2012). Further studies in this area and in other cultural settings are necessary so that we can develop an idea of how WBH can or cannot impact on different contextual settings. As noted, this study has suggested that student self-efficacy levels, rates of homework completion and mathematical performance for the duration of the study improved.

Another suggestion would be to expand the research area to include gender differences. Given the cultural context of this study of segregated schools, it arguably could be both socially and politically correct to provide information that compares the performance of boys and girls. The comparative study could highlight disparities between the genders that could later be addressed socially and politically where it is practicably possible, given the social context of the research.

Further research needs to be conducted in the other Emirates of the UAE, as demographics and regional differences should be considered as factors that could affect levels of motivation. The Emirate of Abu Dhabi is the wealthiest, with its vast amount of wealth in oil and gas, and research needs to investigate what influences students' attitudes towards completing mathematics WBH in comparison to attitudes elsewhere in the UAE. Moreover, the students studied in this research reported having few problems with internet access which, is unlikely to be the case in less affluent regions.

Finally, a qualitative study of student and instructor responses to questions related to mathematics WBH versus PBH would be beneficial to the broader research community since many studies conducted have been quantitative. Also, as in this study, the results on student perceptions have been taken from surveys that used a Likert-scale ordering of preference to analyse the responses quantitatively (Bonham et al., 2003; Demirci, 2010; Dufresne et al., 2002; Hauk & Segalla, 2005; Nguyen & Kulm, 2005). Hauk and Segalla (2005) completed one of the first qualitative studies on Online homework that assessed student and teacher perceptions of the usefulness of what they referred to as Online mathematics homework and its ability to engage students. The analysis was completed without the need for further qualitative investigation. Like the Hauk and Segalla (2005) study, this study also identifies issues that would be appropriate for more qualitative investigation. This type of investigation could provide a complete picture of the types of impact WBH has on learning mathematics that could be associated with mathematics learning gains.

Appendices

Appendix 1. Control (PHB) and Intervention (WBH) Groups.

Year	School	Task	*n*	Date	Pre-test PBH	Pre-test WBH	Date	Post-test PBH	Post-test WBH
7	Boys A	Shape: Area of Circle	23	25.11.14	12	11	30.11.14	11	11
	Boys B		18		9	9		9	9
	Girls A	Shape: Area of Circle	25	25.11.14	12	13	30.11.14	12	13
	Girls B		27		14	13		13	13
8	Boys A	Shape:Pythagoras' Theorem	21	04.03.14	10	11	11.03.14	7	10
	Boys B		23		12	11		12	11
	Boys A	Shape2:Similarity	19	27.04.14	9	10	01.05.14	9	10
	Boys B		20		10	10		10	10
	Boys A	Number: Fractions	20	10.09.14	10	10	15.09.14	10	10
	Boys B		17		9	8		9	8
	Girls A	Shape: Pythagoras' Theorem	22	04.03.14	11	11	11.03.14	11	11
	Girls B		20		10	10		13	13
	Girls A	Shape2:Similarity	24	27.04.14	12	12	01.05.14	10	11
	Girls B		26		13	13		12	12
	Girls A	Number: Fractions	23	10.09.14	12	11	15.09.14	12	11
	Girls B		24		10	12		11	12
9	Boys A	Shape: Missing Sides Trigonometry	26	11.03.14	13	13	18.03.14	11	12
	Boys B		23		11	12		10	10
	Boys A	Number:Scientific notation	28	24.09.14	14	14	30.09.14	14	14
	Boys B		25		13	12		13	12
	Girls A	Shape:Missing Sides Trigonometry	27	11.03.14	14	14	18.03.14	13	14
	Girls B		29		14	14		15	14
	Girls A	Number:Scientific notation	25	24.09.14	12	12	30.09.14	13	12
	Girls B		27		13	13		14	13
10	Boys A	Data:Independent probability – tree diagrams	22	19.03.14	11	11	26.03.14	11	11
	Boys B		20		10	10		10	10
	Boys A	Number: Indices & Surds	24	30.09.14	12	12	07.10.14	10	12
	Boys B		25		12	13		7	13
	Boys A	Algebra:Quadratic equations	27	28.10.14	14	13	03.11.14	10	12
	Boys B		25		13	12		13	12
	Boys A	Algebra*:Y=mx +c	17	19.01.15	8	9	26.01.15	4*	7
	Boys B		14		7	7		2*	5
	Boys A	Shape: Sin & Cos rule	22	09.03.15	11	11	16.03.15	10	11
	Boys B		20		10	10		8	10
	Boys A	Shape*:Investigating Trig functions	10	29.04.15	5	5	06.05.15	5	5
	Boys B		7		4	3		4	3
10	Girls A	Data: Independent probability – tree diagrams	29	19.03.14	15	14	26.03.14	15	14
	Girls B		23		11	12		11	12
	Girls A	Number: Indices & Surds	27	30.09.14	13	14	07.10.14	13	13
	Girls B		27		13	14		13	14
	Girls A	Algebra:Quadratic equations	30	28.10.14	15	15	03.11.14	11	14
	Girls B		27		14	13		11	12
	Girls A	Shape: Sin & Cos rule	24	09.03.15	12	12	16.03.15	10	12
	Girls B		24		12	12		9	12
	Girls A	Shape*:Investigating Trig functions	14	26.04.15	7	7	06.05.15	7	7
	Girls B		10		5	5		5	5
11	Boys A	Algebra: Rules of logs	17	19.03.14	8	9	26.03.14	6	9
	Boys B		15		8	7		8	7
	Boys A	Data:Factorial Notation	20	16.11.14	10	10	23.11.14	8	9
	Boys B		17		8	9		8	9
	Boys A	Algebra: Differentiating Polynomials	18	10.02.15	9	9	17.02.15	9	9
	Boys B		18		9	9		9	9
	Boys A	Data*:Investigating standard deviation	14	25.02.15	7	7	04.03.15	3*	6*
	Boys B		12		6	6		1*	4*
	Boys A	Shape*: Hyperbola investigation	9	17.05.15	5	4	24.05.15	4*	3*
	Boys B		12		6	6		5*	3*
11	Girls A	Algebra:Rules of logs	22	19.03.14	11	11	26.03.14	9	11
	Girls B		27		13	14		13	14
	Girls A	Data::Factorial Notation	20	16.11.14	10	10	23.11.14	8	9
	Girls B		23		11	12		10	12
	Girls A	Algebra: Differentiating Polynomials	25	10.02.15	12	13	17.02.15	12	13
	Girls B Girls A		20		10	10		10	10
	Girls B	Data*:Investigating standard deviation	16	25.02.15	8	8	04.03.15	2*	6*
	Girls A		14		7	7		3*	7*
	Girls B	Shape*: Hyperbola investigation	10	17.05.15	5	5	24.05.15	3*	5
			12		6	6		4*	6

Appendix 2 – Web-based Homework and Paper-based Homewok Tasks

Pretest & Posttest tasks		
Grade 7	date: 25.11.14	30.11.14
Perimeter, Area & Volume		
PBH – Area of a circle, student workbook, page 53, questions 1-6		
WBH		
http://www.myimaths.com/tasks/library/loadTask.asp?title=areas/areaofcircleOH&taskID=1083		
Grade 8		
(Number) Fractions	date: 10.09.14	15.09.14
PBH		
Addition & subtraction of Fractions page 1 student workbook, questions 1-8.		
WBH		
http://www.myimaths.com/tasks/library/loadTask.asp?title=fractions/addingFractionsOH&taskID=1017		
(Shape) Pythagoras' Theorem	date: 04.03.14	11.03.14
PBH		
Using Pythagoras' Theorem to calculate one of the short sides P68 student workbook questions 1-4.		
WBH		
http://www.myimaths.com/tasks/library/loadTask.asp?title=pythagoras/INTpythagorasTheoremOH&taskID=1112		
(Shape) Similarity		
PBH – Similarity Worksheet		
WBH	date: 27.04.14	01.05.14
http://www.myimaths.com/tasks/library/loadTask.asp?title=similarity/similarityOH&taskID=1119		
Grade 9		
(Number) Scientific notation	date: 24.09.14	30.09.14
PBH - Scientific (or Standard) Notation student workbook page 2, questions 3-11.		
WBH		
http://www.myimaths.com/tasks/library/loadTask.asp?title=standardform/standardFormCalculationsOH&taskID=1050		
(Shape) Missing Sides Trigonometry	date: 11.03.14	18.03.14
PBH - Finding an unknown side part 1, student workbook page 70, questions 1-8		

WBH- http://www.myimaths.com/tasks/library/loadTask.asp?title=trigonometry/trigsidesOH&taskID=1133		
Grade 10		
(Number) Indices & Surds	date: 30.09.14	07.10.14
PBH – Binomial Products & Rationalising the Denominator, student workbook, page 5.		
WBH		
http://www.myimaths.com/tasks/library/alevel/lib/loadTask.asp?title=alevel/core1/indices/indices5Surds2OH&taskID=2037		
(Algebra) Quadratic equations	date: 28.10.14	03.11.14
PBH – Quadratic Equations Using Factors, student workbook, page 33 & 34 questions 1-4.		
WBH		
http://www.myimaths.com/tasks/library/loadTask.asp?title=factorising/solveQuadsByFactoringOH&taskID=1181		
(Data) Independent probability – tree diagrams	date: 19.03.14	26.03.14
PBH – Independent probability tree diagrams worksheet.		
WBH		
http://www.myimaths.com/tasks/library/loadTask.asp?title=probIndependent/probIndependentOH&taskID=1208		
Grade 11 Academic		
(Algebra) Rules of logs	date: 16.11.14	23.11.14
PBH – Student activity book + student workbook		
http://www.myimaths.com/tasks/library/alevel/lib/loadTask.asp?title=alevel/core2/logs/logs2logsOH&taskID=2062		
http://www.myimaths.com/tasks/library/alevel/lib/loadTask.asp?title=alevel/core2/logs/logs3EquationsOH&taskID=2063		
Grade 11 Applied	date: 27.03.14	02.04.14
Data (Counting Principles) Factorial Notation		
PBH – Factorial Notation & nPr (permutations), student workbook pages 1-4		
WBH http://www.myimaths.com/tasks/library/alevel/lib/loadTask.asp?title=alevel/stats1/permscombs/permcomb1PermsOH&taskID=2108		

Year	School	GeoGebra Task	N	date	Pre-test PBH	Pre-test WBH	date	Post-test PBH	Post-test WBH
10	Boys A	Y=mx +c	17	19.01.15	8	9	26.01.15	4*	7
	Boys B		14		7	7		2*	5
	Boys A	Investigating Trig functions	14	26.04.15	7	7	06.05.15	7	7
	Boys B		10	29.04.15	5	5	06.05.15	5	5
	Girls A		14	26.04.15	7	7	06.05.15	7	7
	Girls B								
			7		4	3		4	3
11	Girls A	Hyperbola Investigation	16	25.02.15	8	8	04.03.15	2*	6*
	Girls B		14		7	7		3*	7
	Boys A	Investigating Trig functions	17		7	7		3*	6*
	Boys B		12		6	6		1*	4*
	Girls A	Investigating standard deviation	10	17.05.15	5	5	24.05.15	3*	5
	Girls B		12		6	6		4*	6

Appendix 3 - Percentage of Homework given to Students in TIMMS Participating Countries

Table 1: Fraction of students who get homework in mathematics and science.

Country	Every or almost every lesson	About half the lessons	Some lessons	Homework not given
		MATHEMATICS		
Australia	16.35	18.63	51.77	13.24
Austria	81.94	15.95	2.11	0.00
Czech Rep	20.75	57.92	21.34	0.00
Denmark	64.59	30.76	4.65	0.00
Germany	92.37	6.50	1.13	0.00
Hungary	93.03	3.47	1.94	1.55
Italy	57.11	17.34	23.42	2.13
Japan	60.56	22.05	15.78	1.62
Netherlands	0.49	2.47	33.43	63.62
New Zealand	14.45	9.62	57.61	18.31
Norway	39.81	39.81	20.22	0.15
Slovak Republic	64.50	23.05	11.70	0.74
Sweden	4.04	12.86	80.98	2.12
United States	75.47	9.94	10.53	4.06
England	1.97	13.91	80.91	3.21
Scotland	8.29	28.38	62.10	1.23

Appendix 4 – Equation of a Snowman Worksheet

The Equation of a Snowman

Frosty the snowman, was a jolly happy soul. He was made of points and circles though and he'll come to life with math...

Steps: (Check off each box as you go.)

- ☐ **Click** *View* and choose *Grid*.
- ☐ **Click** *Options* then go to *Labelling* and **click** on *No new objects*.
- ☐ On the bottom of the screen next to *Input* **type** x^2 + y^2 = 9 and hit Enter. This creates a circle centred at the origin with a radius of 3.
- ☐ To plot, **type** the equation of a circle centred at (0,-7) with a radius of 4.
    - Equation:
- ☐ **Type** the equation of a circle centred at (0,-16) with a radius of 5.
    - Equation:
- ☐ **Type** the equation of a circle centred at (-1, 1) with a radius of 0.8.
    - Equation:
- ☐ **Type** the equation of a circle centred at (1, 1) with a radius of 0.8.
    - Equation:
- ☐ **Type** the equation of a circle centred at (0, 0) with a radius of 0.5.
    - Equation:
- ☐ **Type** the equation of a circle centred at (-1.5,-1.5) with a radius of 0.4.
    - Equation:
- ☐ **Type** the equation of a circle centred at (1.5,-1.5) with a radius of 0.4.
- ☐ **Type** the equation of a circle centred at (-.75,-2) with a radius of 0.4.
- ☐ **Type** the equation of a circle centred at (.75,-2) with a radius of 0.4.

- ☐ **Type** the equation of a circle centred at (0,-2) with a radius of 0.4.
- ☐ **Type** the equation of a circle centred at (0,-5) with a radius of 0.6.
- ☐ **Type** the equation of a circle centred at (0,-7) with a radius of 0.6.
- ☐ **Type** the equation of a circle centred at (0,-9) with a radius of 0.6.
- ☐ To plot the points for the arms **type** (4,-7)
- ☐ **Type** (-4,-7)
- ☐ **Type** (10,0)
- ☐ **Type** (-10,-14)
- ☐ **Type** (-11,-14)
- ☐ **Type** (-11,-15)
- ☐ **Type** (-9,-16)
- ☐ **Type** (10, 1)
- ☐ **Type** (11.5,1.5)
- ☐ **Type** (11.5,0)
- ☐ To create line segments for the arms **type (**so that it is written as) segment [(-4,-7), (-10,-14)].
- ☐ **Type** segment [(-10,-14), (-11,-15)].
- ☐ **Type** segment[(-10,-14),(-9,-16)].
- ☐ **Type** segment[(-10,-14), (-11,-14)].
- ☐ **Type** segment [(4,-7), (10, 0)].
- ☐ **Type** segment [(10, 0), (10, 1)].
- ☐ **Type** segment [(10, 0), (11.5, 1.5)].
- ☐ **Type** segment [(10, 0), (11.5, 0)].

Now be creative and unique. Give Frosty a little something special and really make this your creation. Feel free to use any of the functions in GeoGebra!

- ☐ **Click** *View* and choose *Grid*.
- ☐ **Click** *View* and choose *Axis*.

And then we have our friend Frosty!

Frosty Wrap Up:

The general equation of a circle is:

Assume that we have the unit circle centered at the origin [$x^2 + y^2 = 1$], then

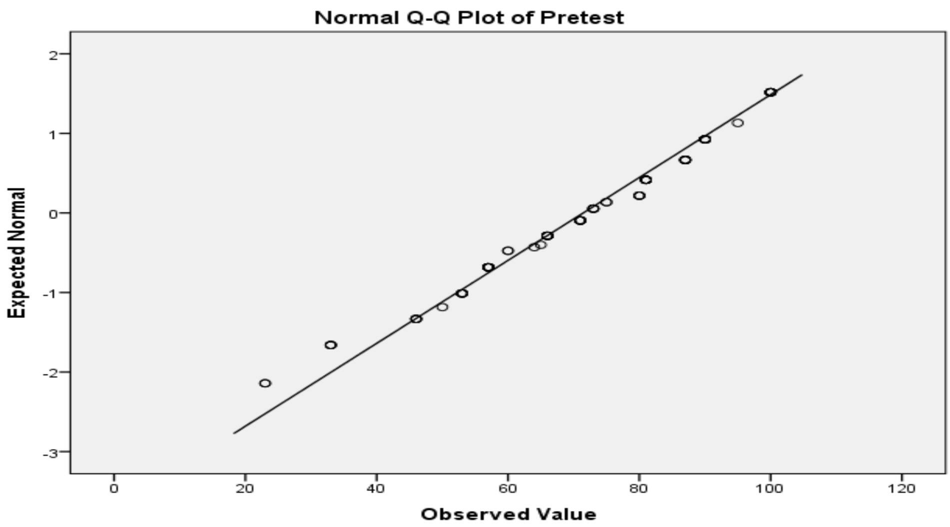
1.) if it is shifted 4 units to the right the equation becomes:

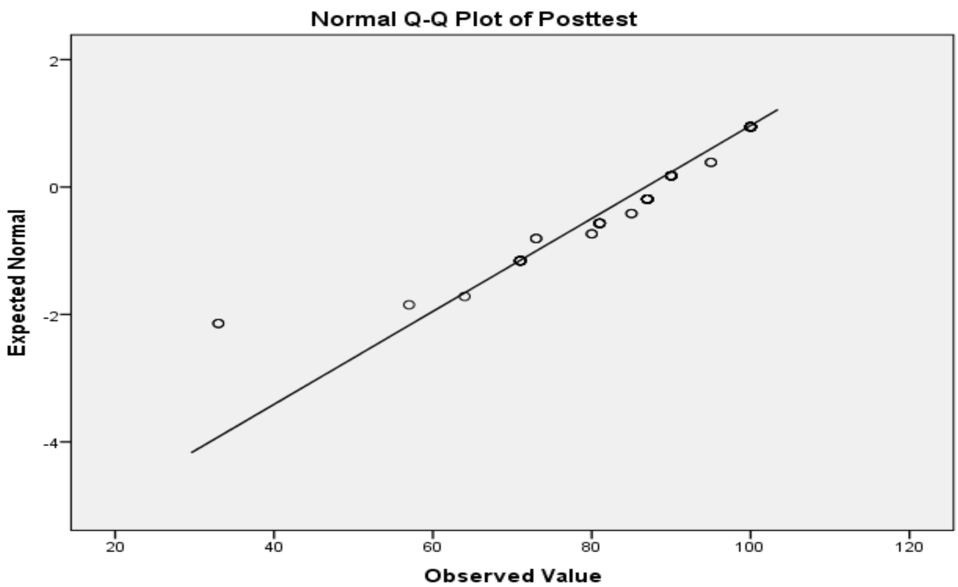
2.) if it is shifted 3 units down the equation becomes:

3.) if it's radius is increased by 6 the equation becomes:

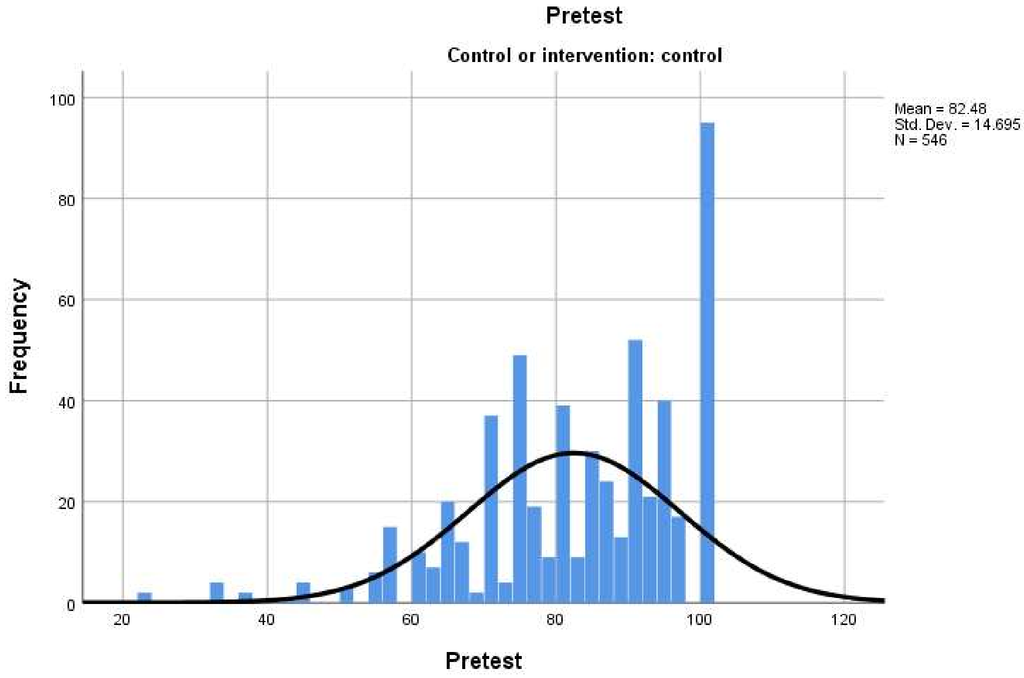
4.) if it is shifted 2 units up, 7 units left, and its radius is increased by 3 the equation becomes:

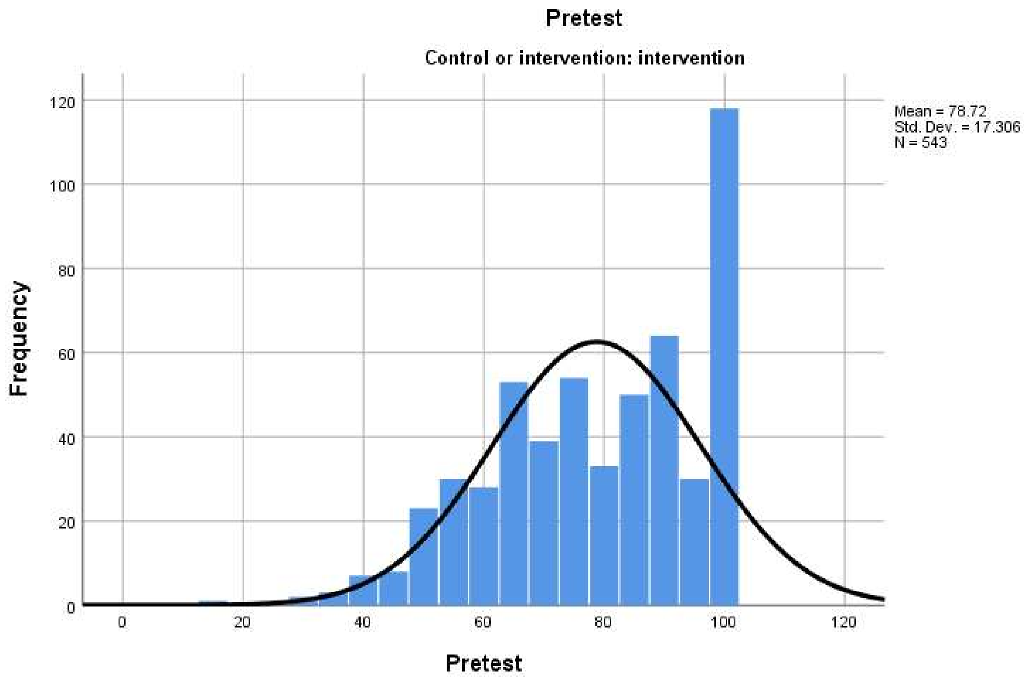
Appendix 5 - Q-Q Plots Pre-Test, Post-test

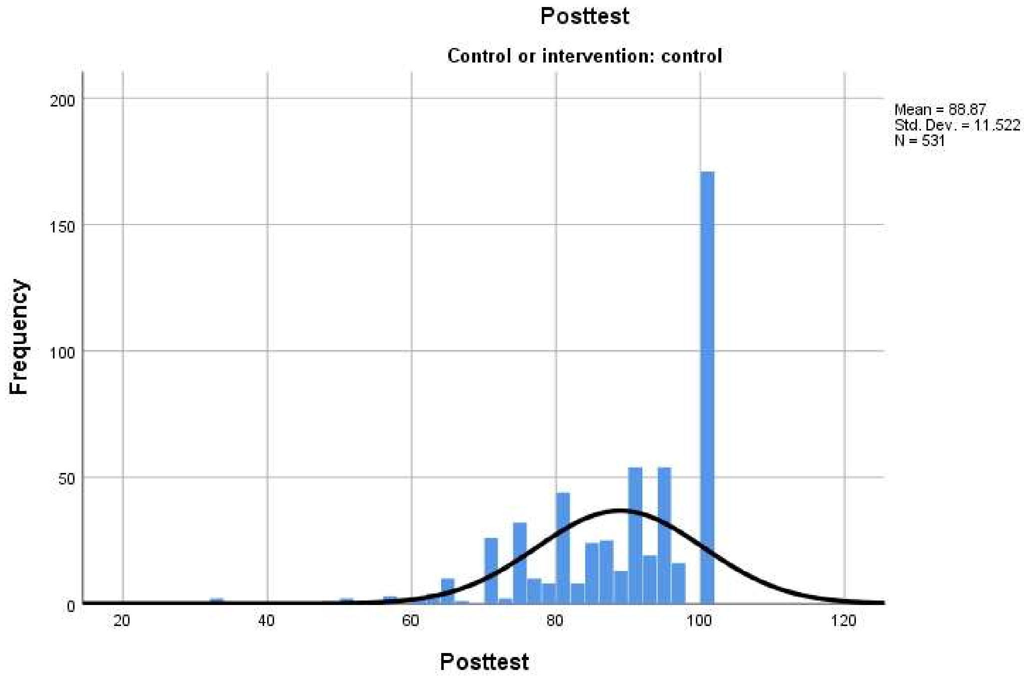


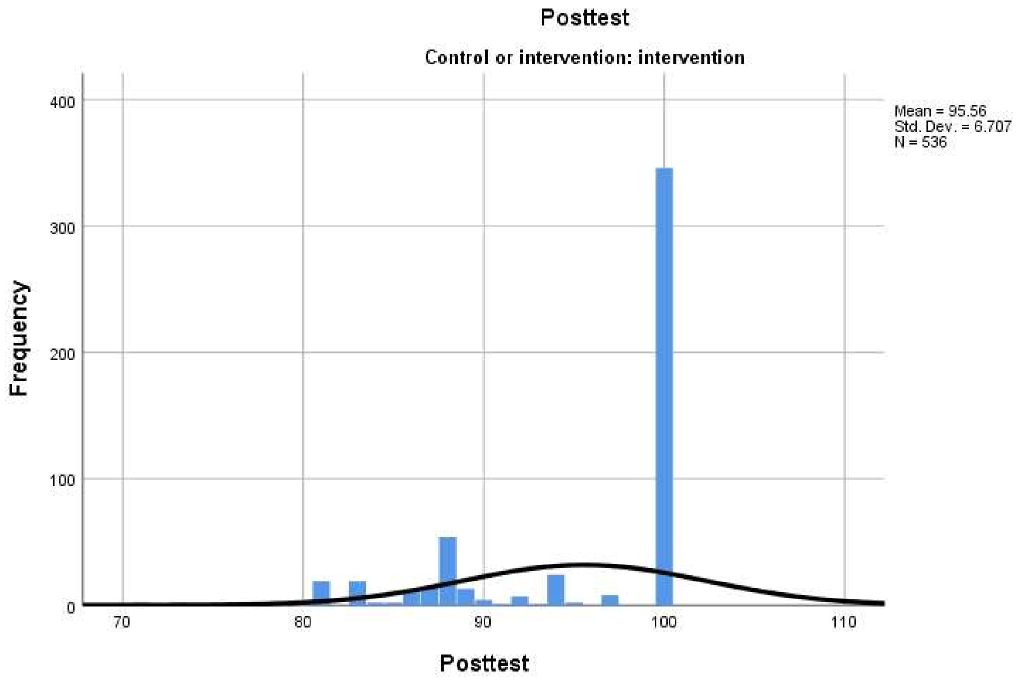


Appendix 6 - Histogram of Pre-test & Post-test PBH and WBH Groups

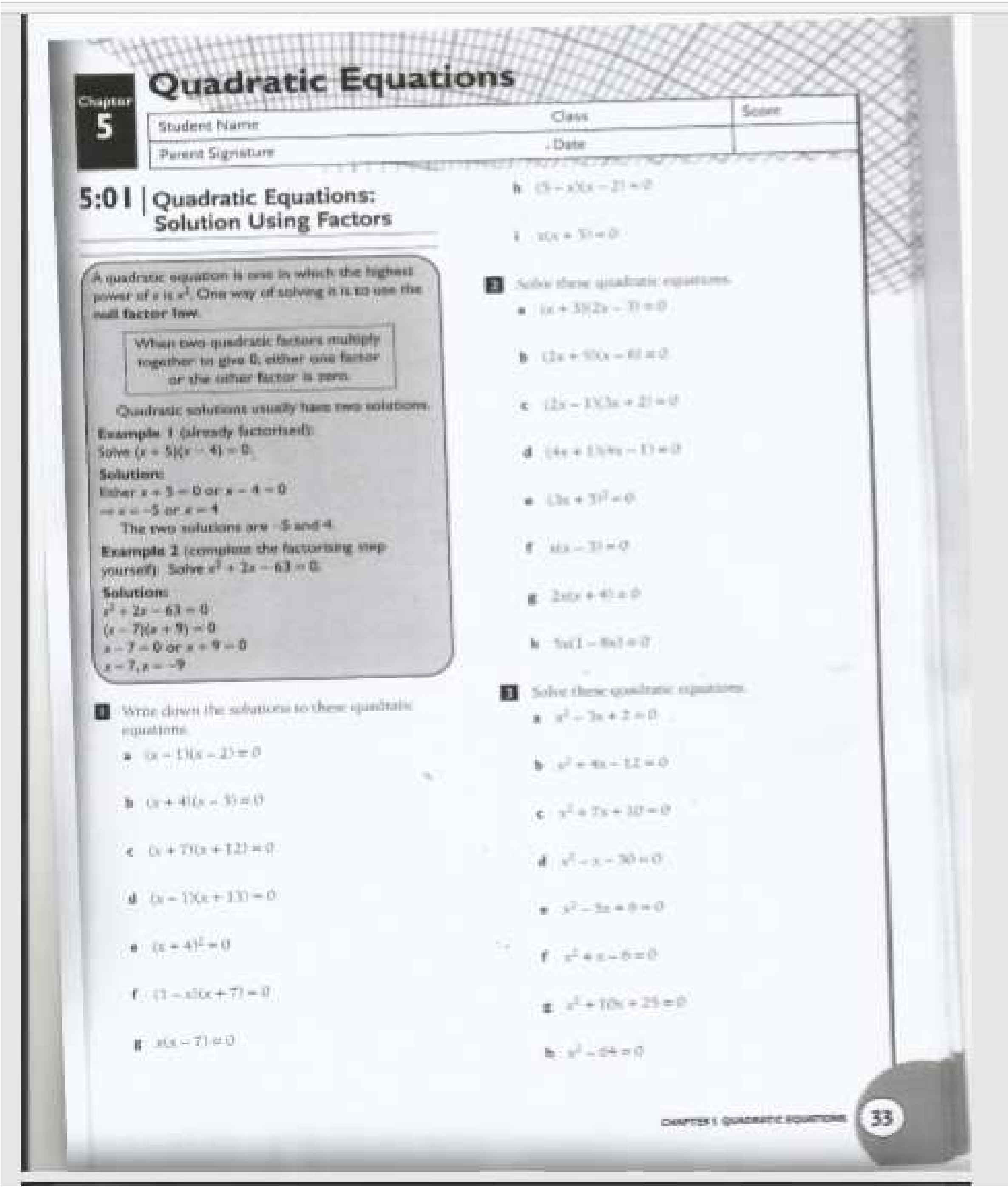





Posttest
Control or intervention: control
Mean = 88.87
Std. Dev. = 11.522
N = 531
Frequency
200
150
100
50
0
20
40
60
80
100
120
Posttest


Posttest
Control or intervention: intervention
Mean = 95.56
Std. Dev. = 6.707
N = 536
Frequency
400
300
200
100
0
70
80
90
100
110
Posttest

Appendix 7 - Year 9 Paper-based Homework on Factorising Quadratic Equations (Question 3)



Quadratic Equations

Chapter 5

Student Name	Class	Score
Parent Signature	Date	

5:01 | Quadratic Equations: Solution Using Factors

A quadratic equation is one in which the highest power of x is x^2. One way of solving it is to use the **null factor law**.

> When two quadratic factors multiply together to give 0, either one factor or the other factor is zero.

Quadratic solutions usually have two solutions.

Example 1 (already factorised):
Solve $(x + 5)(x - 4) = 0$.

Solution:
Either $x + 5 = 0$ or $x - 4 = 0$
$\Rightarrow x = -5$ or $x = 4$
The two solutions are -5 and 4.

Example 2 (complete the factorising step yourself): Solve $x^2 + 2x - 63 = 0$.

Solution:
$x^2 + 2x - 63 = 0$
$(x - 7)(x + 9) = 0$
$x - 7 = 0$ or $x + 9 = 0$
$x = 7, x = -9$

1 Write down the solutions to these quadratic equations.

a $(x - 1)(x - 2) = 0$

b $(x + 4)(x - 3) = 0$

c $(x + 7)(x + 12) = 0$

d $(x - 1)(x + 13) = 0$

e $(x + 4)^2 = 0$

f $(1 - x)(x + 7) = 0$

g $x(x - 7) = 0$

h $(5 - x)(x - 2) = 0$

i $x(x + 3) = 0$

2 Solve these quadratic equations.

a $(x + 3)(2x - 3) = 0$

b $(2x + 5)(x - 6) = 0$

c $(2x - 1)(3x + 2) = 0$

d $(4x + 1)(4x - 1) = 0$

e $(3x + 3)^2 = 0$

f $x(x - 3) = 0$

g $2x(x + 4) = 0$

h $5x(1 - 8x) = 0$

3 Solve these quadratic equations.

a $x^2 - 3x + 2 = 0$

b $x^2 + 4x - 12 = 0$

c $x^2 + 7x + 10 = 0$

d $x^2 - x - 30 = 0$

e $x^2 - 5x + 6 = 0$

f $x^2 + x - 6 = 0$

g $x^2 + 10x + 25 = 0$

h $x^2 - 64 = 0$

CHAPTER 5 QUADRATIC EQUATIONS 33

Appendix 8 - Comparing Means WBH versus PBH Pre-test, Post

Group Statistics								
Year					N	Mean	Std. Deviation	Std. Error Mean
year 7	Boys A	shape	Pre-test	intervention	11	67.64	19.382	5.844
				control	12	65.42	21.39	6.175
			Post-test	intervention	11	91	9.56	2.883
				control	12	75.25	17.321	5
	Boys B	shape	Pre-test	intervention	9	70.44	18.035	6.012
				control	9	69.56	21.143	7.048
			Post-test	intervention	9	89.44	11.588	3.863
				control	9	79.78	19.98	6.66
	Girls A	shape	Pre-test	intervention	13	78.38	17.961	4.981
				control	12	70.42	23.547	6.797
			Post-test	intervention	13	93.23	6.572	1.823
				control	12	84.25	12.707	3.668
	Girls B	shape	Pre-test	intervention	14	72.79	14.921	3.988
				control	13	74.85	18.814	5.218
			post test	intervention	14	94.07	7.216	1.929
				control	12	84.67	13.296	3.838
year 8	Boys A	number	Pre-test	intervention	10	77.8	15.179	4.8
				control	10	71	18.074	5.715
			Post-test	intervention	10	96.4	3.406	1.077
				control	10	80	13.944	4.41
		shape	Pre-test	intervention	20	77.05	18.777	4.199
				control	20	80.25	16.332	3.652
			Post-test	intervention	19	96.21	5.731	1.315
				control	17	87.06	10.697	2.594
	Boys B	number	Pre-test	intervention	8	85.75	13.771	4.869
				control	9	72.78	16.604	5.535
			Post-test	intervention	8	96.63	4.069	1.438
				control	9	80	13.463	4.488
		shape	Pre-test	intervention	20	72.1	24.787	5.543
				control	21	81.81	18.422	4.02
			Post-test	intervention	20	96.35	4.955	1.108
				control	21	86.24	15.073	3.289
	Girls A	number	Pre-test	intervention	11	78.27	19.142	5.772
				control	12	85	11.282	3.257
			Post-test	intervention	11	97.91	5.088	1.534
				control	12	90.42	11.766	3.397
		shape	Pre-test	intervention	23	77.91	18.27	3.81
				control	23	82.3	12.356	2.576
			Post-test	intervention	22	95.64	5.908	1.26
				control	21	88.71	8.816	1.924
	Girls B	number	Pre-test	intervention	12	81.5	20.699	5.975
				control	12	87.92	11.572	3.34
			Post-test	intervention	12	99.5	1.168	0.337
				control	11	91.82	9.816	2.96
		shape	Pre-test	intervention	22	77.86	17.575	3.747
				control	23	84.48	11.735	2.447
			Post-test	intervention	21	94.48	7.068	1.542
				control	22	90	11.67	2.488

year 9	Boys A	number	Pre-test	intervention	14	71.93	20.33	5.433
				control	14	76.43	16.458	4.399
			Post-test	intervention	14	93.21	9.448	2.525
				control	14	87.5	12.208	3.263
		shape	Pre-test	intervention	13	78.77	16.115	4.469
				control	13	82.38	10.413	2.888
			Post-test	intervention	12	95.75	7.689	2.219
				control	11	88.64	9.352	2.82
	Boys B	number	Pre-test	intervention	12	77.83	19.357	5.588
				control	13	86.92	12.835	3.56
			Post-test	intervention	12	93.67	9.355	2.701
				control	13	92.69	5.991	1.662
		shape	Pre-test	intervention	12	73.58	16.172	4.668
				control	11	81	10.412	3.139
			Post-test	intervention	10	91.5	8.96	2.833
				control	10	88.1	8.724	2.759
	Girls A	number	Pre-test	intervention	12	78.92	15.312	4.42
				control	13	88.85	11.575	3.21
			Post-test	intervention	12	95.25	8.593	2.481
				control	13	95.38	8.771	2.433
		shape	Pre-test	intervention	14	76.71	20.488	5.476
				control	13	87.38	10.634	2.949
			Post-test	intervention	14	93.93	8.453	2.259
				control	13	93.69	6.524	1.809
	Girls B	number	Pre-test	intervention	13	86.08	16.894	4.686
				control	13	83.08	14.221	3.944
			Post-test	intervention	13	95.62	8.332	2.311
				control	13	89.62	11.08	3.073

year 9	Boys A	number	Pre-test	intervention	14	71.93	20.33	5.433
				control	14	76.43	16.458	4.399
			Post-test	intervention	14	93.21	9.448	2.525
				control	14	87.5	12.208	3.263
		shape	Pre-test	intervention	13	78.77	16.115	4.469
				control	13	82.38	10.413	2.888
			Post-test	intervention	12	95.75	7.689	2.219
				control	11	88.64	9.352	2.82
	Boys B	number	Pre-test	intervention	12	77.83	19.357	5.588
				control	13	86.92	12.835	3.56
			Post-test	intervention	12	93.67	9.355	2.701
				control	13	92.69	5.991	1.662
		shape	Pre-test	intervention	12	73.58	16.172	4.668
				control	11	81	10.412	3.139
			Post-test	intervention	10	91.5	8.96	2.833
				control	10	88.1	8.724	2.759
	Girls A	number	Pre-test	intervention	12	78.92	15.312	4.42
				control	13	88.85	11.575	3.21
			Post-test	intervention	12	95.25	8.593	2.481
				control	13	95.38	8.771	2.433
		shape	Pre-test	intervention	14	76.71	20.488	5.476
				control	13	87.38	10.634	2.949
			Post-test	intervention	14	93.93	8.453	2.259
				control	13	93.69	6.524	1.809
	Girls B	number	Pre-test	intervention	13	86.08	16.894	4.686
				control	13	83.08	14.221	3.944
			Post-test	intervention	13	95.62	8.332	2.311
				control	13	89.62	11.08	3.073

Appendix 9 - Comparing means highlighted anomalies

Group Statistics

Year	School	Task		Control or Intervention	*N*	Mean	*SD*	Std. Error Mean
Grade 7	Boys School A	Shape	Pre-test	Intervention	11	67.64	19.382	5.844
				Control	12	65.42	21.39	6.175
			Post-test	Intervention	11	91	9.56	2.883
				Control	12	75.25	17.321	5
	Boys School B	Shape	Pre-test	Intervention	9	70.44	18.035	6.012
				Control	9	69.56	21.143	7.048
			Post-test	Intervention	9	89.44	11.588	3.863
				Control	9	79.78	19.98	6.66
	Girls School A	Shape	Pre-test	Intervention	13	78.38	17.961	4.981
				Control	12	70.42	23.547	6.797
			Post-test	Intervention	13	93.23	6.572	1.823
				Control	12	84.25	12.707	3.668
	Girls School B	Shape	Pre-test	Intervention	14	72.79	14.921	3.988
				Control	13	74.85	18.814	5.218
			Post-test	Intervention	14	94.07	7.216	1.929
				Control	12	84.67	13.296	3.838
Grade 8	Boys School A	Number	Pre-test	Intervention	10	77.8	15.179	4.8
				Control	10	71	18.074	5.715
			Post-test	Intervention	10	96.4	3.406	1.077
				Control	10	80	13.944	4.41
		Shape	Pre-test	Intervention	20	77.05	18.777	4.199
				Control	20	80.25	16.332	3.652
			Post-test	Intervention	19	96.21	5.731	1.315
				Control	17	87.06	10.697	2.594
	Boys School B	Number	Pre-test	Intervention	8	85.75	13.771	4.869
				Control	9	72.78	16.604	5.535
			Post-test	Intervention	8	96.63	4.069	1.438
				Control	9	80	13.463	4.488
		Shape	Pre-test	Intervention	20	72.1	24.787	5.543
				Control	21	81.81	18.422	4.02
			Post-test	Intervention	20	96.35	4.955	1.108
				Control	21	86.24	15.073	3.289
	Girls School A	Number	Pre-test	Intervention	11	78.27	19.142	5.772
				Control	12	85	11.282	3.257
			Post-test	Intervention	11	97.91	5.088	1.534
				Control	12	90.42	11.766	3.397
		Shape	Pre-test	Intervention	23	77.91	18.27	3.81
				Control	23	82.3	12.356	2.576
			Post-test	Intervention	22	95.64	5.908	1.26
				Control	21	88.71	8.816	1.924
	Girls School B	Number	Pre-test	Intervention	12	81.5	20.699	5.975
				Control	12	87.92	11.572	3.34
			Post-test	Intervention	12	99.5	1.168	0.337
				Control	11	91.82	9.816	2.96
		Shape	Pre-test	Intervention	22	77.86	17.575	3.747
				Control	23	84.48	11.735	2.447
			Post-test	Intervention	21	94.48	7.068	1.542
				Control	22	90	11.67	2.488

Grade 9	Boys School A	Number	Pre-test	Intervention	14	71.93	20.33	5.433
				Control	14	76.43	16.458	4.399
			Post-test	Intervention	14	93.21	9.448	2.525
				Control	14	87.5	12.208	3.263
		Shape	Pre-test	Intervention	13	78.77	16.115	4.469
				Control	13	82.38	10.413	2.888
			Post-test	Intervention	12	95.75	7.689	2.219
				Control	11	88.64	9.352	2.82
	Boys School B	Number	Pre-test	Intervention	12	77.83	19.357	5.588
				Control	13	86.92	12.835	3.56
			Post-test	Intervention	12	93.67	9.355	2.701
				Control	13	92.69	5.991	1.662
		Shape	Pre-test	Intervention	12	73.58	16.172	4.668
				Control	11	81	10.412	3.139
			Post-test	Intervention	10	91.5	8.96	2.833
				Control	10	88.1	8.724	2.759
	Girls School A	Number	Pre-test	Intervention	12	78.92	15.312	4.42
				Control	13	88.85	11.575	3.21
			Post-test	Intervention	12	95.25	8.593	2.481
				Control	13	95.38	8.771	2.433
		Shape	Pre-test	Intervention	14	76.71	20.488	5.476
				Control	13	87.38	10.634	2.949
			Post-test	Intervention	14	93.93	8.453	2.259
				Control	13	93.69	6.524	1.809
	Girls School B	Number	Pre-test	Intervention	13	86.08	16.894	4.686
				Control	13	83.08	14.221	3.944
			Post-test	Intervention	13	95.62	8.332	2.311
				Control	13	89.62	11.08	3.073

Grade 10	Boys School A	Number	Pre-test	Intervention	12	82.17	14.615	4.219
				Control	12	83.83	12.496	3.607
			Post-test	Intervention	12	96.33	5.416	1.563
				Control	12	89.5	10.309	2.976
		Algebra	Pre-test	Intervention	13	80.92	11.679	3.239
				Control	14	82.29	14.28	3.816
			Post-test	Intervention	12	96	5.908	1.706
				Control	10	87.2	11.535	3.648
		Shape	Pre-test	Intervention	11	75.18	20.517	6.186
				Control	11	78.18	15.039	4.534
			Post-test	Intervention	11	96.18	6.539	1.972
				Control	11	84.91	14.734	4.442
		Measurement & data	Pre-test	Intervention	11	77.55	22.629	6.823
				Control	11	80.91	11.362	3.426
			Post-test	Intervention	11	95	7.197	2.17
				Control	11	87.27	10.09	3.042
	Boys School B	Number	Pre-test	Intervention	13	80	12.543	3.479
				Control	12	85.67	11.727	3.385
			Post-test	Intervention	13	94.15	8.735	2.423
				Control	12	92.58	7.549	2.179
		Algebra	Pre-test	Intervention	12	82.67	14.202	4.1
				Control	13	83.38	13.672	3.792
			Post-test	Intervention	12	95.67	6.485	1.872
				Control	13	89.38	10.603	2.941
		Shape	Pre-test	Intervention	10	69.8	24.036	7.601
				Control	10	85.8	12.127	3.835
			Post-test	Intervention	10	95.8	6.763	2.139
				Control	10	175.2	250.5	79.215
		Measurement & data	Pre-test	Intervention	10	84	15.67	4.955
				Control	10	75.5	15.537	4.913
			Post-test	Intervention	10	97	4.243	1.342
				Control	10	83	14.568	4.607
	Girls School A	Number	Pre-test	Intervention	14	80	17.776	4.751
				Control	13	86.23	12.377	3.433
			Post-test	Intervention	14	96.86	5.157	1.378
				Control	13	88.85	11.074	3.071
		Algebra	Pre-test	Intervention	15	77.6	13.757	3.552
				Control	16	82.13	10.966	2.741
			Post-test	Intervention	15	94.93	6.497	1.677
				Control	16	87.13	10.658	2.664
		Shape	Pre-test	Intervention	12	74.83	19.6	5.658
				Control	12	85	18.645	5.382
			Post-test	Intervention	12	92.92	9.643	2.784
				Control	12	91.75	11.355	3.278
		Measurement & data	Pre-test	Intervention	26	80.73	16.715	3.278
				Control	26	82.5	12.349	2.422
			Post-test	Intervention	26	97.42	4.981	0.977
				Control	26	88.27	10.094	1.98
	Girls School B	Number	Pre-test	Intervention	14	80.86	15.206	4.064
				Control	14	85.29	13.898	3.714
			Post-test	Intervention	14	96.07	5.47	1.462
				Control	14	88.93	13.041	3.485
		Algebra	Pre-test	Intervention	13	80.92	13.871	3.847
				Control	14	84.36	10.959	2.929
			Post-test	Intervention	13	97.23	5.262	1.46
				Control	14	87.36	9.605	2.567
		Shape	Pre-test	Intervention	12	79.67	19.933	5.754
				Control	12	83.17	18.809	5.43
			Post-test	Intervention	12	97.67	5.449	1.573
				Control	12	89.17	15.105	4.36

Grade 11	Boys School A	Number	Pre-test	Intervention	9	82.67	17.029	5.676
				Control	8	91.25	10.264	3.629
			Post-test	Intervention	9	93.89	6.936	2.312
				Control	8	95	6.547	2.315
		Algebra	Pre-test	Intervention	9	78.78	16.687	5.562
				Control	9	84.56	8.904	2.968
			Post-test	Intervention	9	94.33	8.5	2.833
				Control	9	92.56	7.108	2.369
	Boys School B	Number	Pre-test	Intervention	7	87.57	12.501	4.725
				Control	8	94.38	8.634	3.053
			Post-test	Intervention	7	99.14	2.268	0.857
				Control	8	96.88	5.939	2.1
		Algebra	Pre-test	Intervention	9	83.22	13.872	4.624
				Control	9	86.11	8.054	2.685
			Post-test	Intervention	9	97.22	5.954	1.985
				Control	9	92.89	9.427	3.142
	Girls School A	Number	Pre-test	Intervention	11	80.91	17.061	5.144
				Control	11	88	11.446	3.451
			Post-test	Intervention	11	96.09	5.804	1.75
				Control	11	95	5.916	1.784
		Algebra	Pre-test	Intervention	13	85.92	14.215	3.943
				Control	12	88.75	11.104	3.205
			Post-test	Intervention	13	98.15	3.508	0.973
				Control	12	94.67	5.263	1.519
	Girls School B	Number	Pre-test	Intervention	14	82.71	13.731	3.67
				Control	13	89.62	11.808	3.275
			Post-test	Intervention	14	97.43	4.536	1.212
				Control	13	93.08	9.473	2.627
		Algebra	Pre-test	Intervention	10	86.2	9.601	3.036
				Control	10	84.7	11.823	3.739
			Post-test	Intervention	10	95.9	5.896	1.865
				Control	10	90.9	9.374	2.964

Appendix 10- Comparing Means for the GeoGebra WBH and PBH

Group Statistics

Year	School	Task		Control or Intervention	*N*	Mean	*SD*	Std. Error Mean
Grade 10	Boys School A	Algebra	Pre-test	Control	9	90.00	7.071	2.357
				Intervention	9	74.11	21.456	7.152
			Post-test	Control	7	97.86	2.673	1.010
				Intervention	7	98.57	3.780	1.429
		Shape	Pre-test	Control	5	80.00	20.917	9.354
				Intervention	5	74.20	19.741	8.828
			Post-test	Control	5	100.00	.000	.000
				Intervention	5	99.40	.548	.245
	Boys School B	Algebra	Pre-test	Control	7	94.29	9.759	3.689
				Intervention	7	72.86	24.361	9.208
			Post-test	Control	2	100.00	.000	.000
				Intervention	5	92.40	7.635	3.415
		Shape	Pre-test	Control	4	91.25	8.539	4.270
				Intervention	3	84.67	11.547	6.667
			Post-test	Control	4	98.75	2.500	1.250
				Intervention	3	98.00	.000	.000
				Control	7	78.57	20.148	7.615

Grade 11	Boys School A	Measurement & data	Pre-test	Intervention	6	96.50	3.391	1.384
			Post-test	Control	3	93.33	11.547	6.667
				Intervention	5	100.00	.000	.000
	Boys School B	Measurement & data	Pre-test	Control	6	70.83	21.545	8.796
				Intervention	6	94.83	4.021	1.641
			Post-test	Control	1	100.00	.	.
				Intervention	4	100.00	.000	.000
	Girls School A	Measurement & data	Pre-test	Control	8	87.50	14.880	5.261
				Intervention	8	90.13	9.978	3.528
			Post-test	Control	2	100.00	.000[a]	.000
				Intervention	6	100.00	.000[a]	.000
	Girls School B	Measurement & data	Pre-test	Control	7	85.71	15.119	5.714
				Intervention	7	94.71	4.192	1.584
			Post-test	Control	3	100.00	.000[a]	.000
				Intervention	6	100.00	.000[a]	.000

a. t cannot be computed because the standard deviations of both groups are 0.

Appendix 11- Independent Samples T-test

Year					*t* -test for Equality of Means					
					t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
										Lower
Grade 7	Boys School A	Shape	Pre-test	Equal variances not assumed	0.261	20.999	0.797	2.22	8.502	−15.461
			Post-test	Equal variances not assumed	2.729	17.411	0.014	15.75	5.772	3.595
	Boys School B	Shape	Pre-test	Equal variances not assumed	0.096	15.612	0.925	0.889	9.263	−18.789
			Post-test	Equal variances not assumed	1.256	12.835	0.232	9.667	7.699	−6.988
	Girls School A	Shape	Pre-test	Equal variances not assumed	0.945	20.554	0.355	7.968	8.427	−9.581
			Post-test	Equal variances not assumed	2.192	16.197	0.043	8.981	4.096	0.306
	Girls School B	Shape	Pre-test	Equal variances not assumed	−.314	22.9	0.757	−2.060	6.567	−15.650
			Post-test	Equal variances not assumed	2.189	16.372	0.043	9.405	4.296	0.315
Grade 8	Boys School A	Number	Pre-test	Equal variances not assumed	0.911	17.478	0.375	6.8	7.464	−8.914
			Post-test	Equal variances not assumed	3.613	10.07	0.005	16.4	4.539	6.296
		Shape	Pre-test	Equal variances not assumed	−.575	37.283	0.569	−3.200	5.565	−14.472
			Post-test	Equal variances not assumed	3.146	23.873	0.004	9.152	2.909	3.147
	Boys School B	Number	Pre-test	Equal variances not assumed	1.76	14.944	0.099	12.972	7.371	−2.745
			Post-test	Equal variances not assumed	3.528	9.612	0.006	16.625	4.713	6.067
		Shape	Pre-test	Equal variances not assumed	−1.418	35.037	0.165	−9.710	6.847	−23.609
			Post-test	Equal variances not assumed	2.913	24.465	0.008	10.112	3.471	2.956
	Girls School A	Number	Pre-test	Equal variances not assumed	−1.015	15.915	0.325	−6.727	6.627	−20.782
			Post-test	Equal variances not assumed	2.01	15.248	0.062	7.492	3.727	−.440
		Shape	Pre-test	Equal variances not assumed	−.955	38.643	0.346	−4.391	4.599	−13.697
			Post-test	Equal variances not assumed	3.01	34.745	0.005	6.922	2.299	2.253
	Girls School B	Number	Pre-test	Equal variances not assumed	−.937	17.264	0.362	−6.417	6.846	−20.843
			Post-test	Equal variances not assumed	2.579	10.26	0.027	7.682	2.979	1.067
		Shape	Pre-test	Equal variances not assumed	−1.478	36.41	0.148	−6.615	4.475	−15.687
			Post-test	Equal variances not assumed	1.529	34.84	0.135	4.476	2.927	−1.468

Grade 9	Boys School A	Number	Pre-test	Equal variances not assumed	−.644	24.92	0.526	−4.500	6.991	−18.900
			Post-test	Equal variances not assumed	1.385	24.461	0.179	5.714	4.126	−2.792
		Shape	Pre-test	Equal variances not assumed	−.679	20.533	0.504	−3.615	5.321	−14.697
			Post-test	Equal variances not assumed	1.982	19.445	0.062	7.114	3.588	−.385
	Boys School B	Number	Pre-test	Equal variances not assumed	−1.372	18.889	0.186	−9.090	6.626	−22.963
			Post-test	Equal variances not assumed	0.307	18.479	0.762	0.974	3.171	−5.675
		Shape	Pre-test	Equal variances not assumed	−1.318	18.937	0.203	−7.417	5.626	−19.194
			Post-test	Equal variances not assumed	0.86	17.987	0.401	3.4	3.954	−4.908
	Girls School A	Number	Pre-test	Equal variances not assumed	−1.818	20.45	0.084	−9.929	5.463	−21.309
			Post-test	Equal variances not assumed	−.039	22.909	0.969	−.135	3.474	−7.323
		Shape	Pre-test	Equal variances not assumed	−1.716	19.83	0.102	−10.670	6.219	−23.651
			Post-test	Equal variances not assumed	0.082	24.228	0.936	0.236	2.895	−5.735
	Girls School B	Number	Pre-test	Equal variances not assumed	0.49	23.322	0.629	3	6.125	−9.660
			Post-test	Equal variances not assumed	1.561	22.284	0.133	6	3.845	−1.968

Grade 10	Boys School A	Number	Pre-test	Equal variances not assumed	−.300	21.481	0.767	−1.667	5.551	−13.195
			Post-test	Equal variances not assumed	2.033	16.643	0.058	6.833	3.362	−.271
		Algebra	Pre-test	Equal variances not assumed	−.272	24.63	0.788	−1.363	5.006	−11.680
			Post-test	Equal variances not assumed	2.185	12.862	0.048	8.8	4.027	0.091
		Shape	Pre-test	Equal variances not assumed	−.391	18.338	0.7	−3.000	7.67	−19.093
			Post-test	Equal variances not assumed	2.319	13.793	0.036	11.273	4.86	0.834
		Measure ment & data	Pre-test	Equal variances not assumed	−.441	14.741	0.666	−3.364	7.635	−19.661
			Post-test	Equal variances not assumed	2.068	18.083	0.053	7.727	3.737	−.121
	Boys School B	Number	Pre-test	Equal variances not assumed	−1.167	22.994	0.255	−5.667	4.854	−15.708
			Post-test	Equal variances not assumed	0.482	22.912	0.634	1.571	3.259	−5.172
		Algebra	Pre-test	Equal variances not assumed	−.129	22.665	0.899	−.718	5.585	−12.280
			Post-test	Equal variances not assumed	1.802	20.097	0.087	6.282	3.486	−.988
		Shape	Pre-test	Equal variances not assumed	−1.879	13.303	0.082	−16.000	8.514	−34.350
			Post-test	Equal variances not assumed	−1.002	9.013	0.342	−79.400	79.244	−258.623
		Measure ment & data	Pre-test	Equal variances not assumed	1.218	17.999	0.239	8.5	6.978	−6.161
			Post-test	Equal variances not assumed	2.918	10.516	0.015	14	4.798	3.38
	Girls School A	Number	Pre-test	Equal variances not assumed	−1.063	23.252	0.299	−6.231	5.861	−18.349
			Post-test	Equal variances not assumed	2.38	16.694	0.03	8.011	3.367	0.898
		Algebra	Pre-test	Equal variances not assumed	−1.008	26.778	0.322	−4.525	4.487	−13.735
			Post-test	Equal variances not assumed	2.48	25.034	0.02	7.808	3.148	1.324
		Shape	Pre-test	Equal variances not assumed	−1.302	21.945	0.206	−10.167	7.809	−26.364
			Post-test	Equal variances not assumed	0.271	21.438	0.789	1.167	4.3	−7.765
		Measure ment & data	Pre-test	Equal variances not assumed	−.434	46.026	0.666	−1.769	4.076	−9.973
			Post-test	Equal variances not assumed	4.147	36.496	0	9.154	2.207	4.679
	Girls School B	Number	Pre-test	Equal variances not assumed	−.804	25.792	0.429	−4.429	5.506	−15.750
			Post-test	Equal variances not assumed	1.89	17.436	0.076	7.143	3.78	−.816
		Algebra	Pre-test	Equal variances not assumed	−.710	22.854	0.485	−3.434	4.835	−13.440
			Post-test	Equal variances not assumed	3.344	20.449	0.003	9.874	2.953	3.723
		Shape	Pre-test	Equal variances not assumed	−.442	21.926	0.663	−3.500	7.912	−19.911
			Post-test	Equal variances not assumed	1.834	13.816	0.088	8.5	4.635	−1.454

Grade 11	Boys School A	Number	Pre-test	Equal variances not assumed	−1.274	13.331	0.224	−8.583	6.737	−23.102
			Post-test	Equal variances not assumed	−.340	14.931	0.739	−1.111	3.272	−8.087
		Algebra	Pre-test	Equal variances not assumed	−.916	12.214	0.377	−5.778	6.305	−19.488
			Post-test	Equal variances not assumed	0.481	15.514	0.637	1.778	3.694	−6.072
	Boys School B	Number	Pre-test	Equal variances not assumed	−1.209	10.488	0.253	−6.804	5.625	−19.259
			Post-test	Equal variances not assumed	1	9.229	0.343	2.268	2.268	−2.843
		Algebra	Pre-test	Equal variances not assumed	−.540	12.843	0.598	−2.889	5.347	−14.455
			Post-test	Equal variances not assumed	1.166	13.506	0.264	4.333	3.716	−3.665
	Girls School A	Number	Pre-test	Equal variances not assumed	−1.145	17.485	0.268	−7.091	6.195	−20.133
			Post-test	Equal variances not assumed	0.437	19.993	0.667	1.091	2.499	−4.122
		Algebra	Pre-test	Equal variances not assumed	−.556	22.42	0.583	−2.827	5.081	−13.353
			Post-test	Equal variances not assumed	1.933	18.952	0.068	3.487	1.804	−.290
	Girls School B	Number	Pre-test	Equal variances not assumed	−1.403	24.866	0.173	−6.901	4.918	−17.034
			Post-test	Equal variances not assumed	1.504	16.944	0.151	4.352	2.894	−1.755
		Algebra	Pre-test	Equal variances not assumed	0.311	17.272	0.759	1.5	4.816	−8.649
			Post-test	Equal variances not assumed	1.428	15.157	0.174	5	3.502	−2.458

Appendix 12 - Missing Values in GeoGebra WBH versus PBH

Group Statistics

	Control or Intervention	*N*	Mean	*SD*	Std. Error Mean
Pre-test	Control	53	85.09	15.977	2.195
	Intervention	51	84.98	17.284	2.420
Post-test	Control	27	98.52	4.117	.792
	Intervention	41	98.61	3.734	.583

Appendix 13 - Replacing Missing Values in GeoGebra WBH versus PBH

Result Variables

	Result Variable	*N* of Replaced Missing Values	Case Number of Non-Missing Values		*N* of Valid Cases	Creating Function
			First	Last		
1	Pre-test_1	0	1	104	104	SMEA*N*(Pre-test)
2	Post-test_1	36	1	104	104	SMEA*N*(Post-test)

Appendix 14 - Adjusted Means for Control and Intervention Groups (Missing values)

Group Statistics

	Control or Intervention	*N*	Mean	*SD*	Std. Error Mean
Pre-test	Intervention	53	85.09	15.977	2.195
	Control	51	84.98	17.284	2.420
SMEA*N*(Post-test)	Intervention	53	98.603	2.9115	.3999
	Control	51	98.586	3.3400	.4677

Appendix 15 - GeoGebra Group Statistics

Group Statistics

Year	School	Task		Control or Intervention	*N*	Mean	*SD*	Std. Error Mean
Grade 10	Boys School A	Algebra	Pre-test	Control	9	90.00	7.071	2.357
				Intervention	9	74.11	21.456	7.152
			Post-test	Control	7	97.86	2.673	1.010
				Intervention	7	98.57	3.780	1.429
		Shape	Pre-test	Control	5	80.00	20.917	9.354
				Intervention	5	74.20	19.741	8.828
			Post-test	Control	5	100.00	.000	.000
				Intervention	5	99.40	.548	.245
	Boys School B	Algebra	Pre-test	Control	7	94.29	9.759	3.689
				Intervention	7	72.86	24.361	9.208
			Post-test	Control	2	100.00	.000	.000
				Intervention	5	92.40	7.635	3.415
		Shape	Pre-test	Control	4	91.25	8.539	4.270
				Intervention	3	84.67	11.547	6.667
			Post-test	Control	4	98.75	2.500	1.250
				Intervention	3	98.00	.000	.000
Grade 11	Boys School A	Measurement & data	Pre-test	Control	7	78.57	20.148	7.615
				Intervention	6	96.50	3.391	1.384

		Post-test	Control	3	93.33	11.547	6.667
			Intervention	5	100.00	.000	.000
Boys School B	Measurement & data	Pre-test	Control	6	70.83	21.545	8.796
			Intervention	6	94.83	4.021	1.641
		Post-test	Control	1	100.00	.	.
			Intervention	4	100.00	.000	.000
Girls School A	Measurement & data	Pre-test	Control	8	87.50	14.880	5.261
			Intervention	8	90.13	9.978	3.528
		Post-test	Control	2	100.00	.000[a]	.000
			Intervention	6	100.00	.000[a]	.000
Girls School B	Measurement & data	Pre-test	Control	7	85.71	15.119	5.714
			Intervention	7	94.71	4.192	1.584
		Post-test	Control	3	100.00	.000[a]	.000
			Intervention	6	100.00	.000[a]	.000

a. t cannot be computed because the standard deviations of both groups are 0.

Appendix 16 – Student Survey (English and Arabic Versions)

As part of my PhD in Maths Education at the Institute of Education, University of London, I am carrying out a research project. I want to compare Web Based Homework with Paper Based Homework to see what effect it has on learning mathematics.

Confidentiality: The names of the school, the teachers and the pupils involved will not be used in reporting the outcomes of this research. Any information you provide will not be shared with any other member of the school without your permission. If you have any questions or concerns about how the information I collect will be used, or you would just like to know some more about the research, please ask me or email me:

Please respond to the following statements by circling or ticking the appropriate box:

C1 I have access to a computer at home: a) yes b) no if no go to C2

☐ C2 I can gain access to a computer to do my homework a) yes b) no

C3 I am: a) male b) female

Survey

Question/Rate

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't know
E1 I like to do maths homework on the computer.						
E2 Online maths homework motivates me to practice maths.						
E3 I like to receive immediate scores on my maths homework.						
E4 Immediate scores help me to be aware of my performance.						
E5 I like the help and suggestions facility on my Online maths homework.						
E6 I refer to the Online lesson activities to help me complete my homework.						
E7 Online homework feedback helps me to recognise my mistakes.						
E8 Online maths homework gives me more chances to practice mathematical topics.						

E9 I enjoy doing maths homework activities Online more than on paper.						
E10 The Online lesson review helps me to review mathematics concepts.						
E11 I have less anxiety in taking Online homework than paper-based homework.						
E12 Online maths homework helps me evaluate my own understanding and performance.						
E13 I like Online maths homework more than paper-based maths homework.						
E14 I feel I can be better at maths as a result of Online maths homework.						
E15 I am more motivated to do my math homework on the computer than on paper.						
E16 I am easily distracted when doing Online maths homework.						
E17 I discuss my Online maths homework with my classmates and others.						

E18 My parents are keener to monitor my progress in maths because of Online homework						
E19 I get help from my family, friends and others in completing my Online maths homework						
E20 Paper based homework is just as effective as Online maths homework.						
E21 Online maths homework is better than Paper based maths homework						
E22 The use of English language for my Online maths homework is not a problem.						
E23 My teacher encourages the use of Online maths homework.						
E24 My maths has improved as a result of Online homework.						
E25 I spend more time on my maths homework because I can interact with the maths						

Web-based Homework versus Paper-Based Homework in United Arab Emirates Secondary Mathematics

كجزء من رسالة الدكتوراه في "تعليم الرياضيات" من معهد التربية، جامعة لندن، حيث أجري مشروع بحثي, أريد مقارنة انجاز الواجبات المنزلية في مادة الرياضيات باستعمال" الويب" و "الورقة" لنرى ما هو أثرها على تعلم الرياضيات.

السرية: لن يتم استخدام اسم المدرسة والمدرسين والتلاميذ المشاركين في الإبلاغ عن نتائج هذه البحوث. لن يتم تقاسم أية معلومات قمت بتوفيرها مع أي عضو آخر من المدرسة دون الحصول على إذن منك. إذا كان لديك أي أسئلة بشأن كيفية استخدام المعلومات المحصل عليها أو كنت تود أن تعرف أكثر حول البحث، الرجاء ان تسألني أوتراسلني على بريدي الإلكتروني:

الرجاء الإجابة على الأسئلة التالية بالدوران حول مربع الرد المناسب

ا-لدي كمبيوتر في المنزل 1- نعم 2- لا إذا كان جوابك لا فاذهب ل ب

ب- يمكنني الحصول على كمبيوتر لاداء واجبي المنزلي 1- نعم 2- لا

ت- انا 1- ذكر 2- انثى

استبيان الدراسة الاستقصائية

Question/Rate

	متفق بشدة	متفق	محايد	لا أوافق	لا أوافق بشدة	لا أعرف
ارغب في القيام بالواجبات المنزلية في مادة الرياضيات على جهاز الكمبيوتر E1						

						الواجبات المنزلية في الرياضيات على الإنترنت E2 يشجعني على ممارسة الرياضيات.
						أود الحصول فورا على الدرجات التي حصلت E3 عليها في واجباتي.
						التنقيط الفوري يساعدني على معرفة ادائي E4
						أنا أحب المساعدات المسهلة لاداء واجبات E5 الرياضيات عبر الإنترنت
						استعين بالأنشطة المدعمة للدرس على الإنترنت E6 لانجاز واجباتي
						الملاحظات على واجباتي المنزلية عبر الإنترنت تساعدني على التعرف على اخطائي E7
						الواجبات المنزلية في الرياضيات على الإنترنت E8 يعطيني المزيد من الفرص لممارسة المواضيع الرياضية
						استمتع بالقيام بالواجبات المنزلية في E9 الرياضيات على الإنترنت أكثر من على الورق.

						E10 مراجعة الدروس على الإنترنت يساعدني في مراجعة مفاهيم الرياضيات
						E11 لدي قلق اقل في أخذ الواجبات المنزلية عبر الإنترنت من الواجبات المنزلية الورقية
						E12 الواجبات المنزلية في الرياضيات على الإنترنت يساعني على تقييم فهمي وأدائي
						E14 أشعر أنه يمكن أن ا كون أفضل في مادة الرياضيات نتيجة للواجبات المنزلية على الإنترنت
						E15 اتحمس اكثر لاداء واجباتي في الرياضيات على الانترنت من على الورق
						E16 أنا افقد تركيزي بسهولة عند القيام بالواجبات المنزلية في الرياضيات على الإنترنت
						E17 أناقش واجباتي في الرياضيات عبر الإنترنت مع زملائي، وآخرون
						E18 يهتم والدي على رصد التقدم المحرز في الرياضيات بسبب الواجبات المنزلية عبر الإنترنت
						E19 احصل على مساعدة من عائلتي والأصدقاء والآخرين في إكمال واجباتي الرياضيات على

						الإنترنت احصل على مساعدة من عائلتي والأصدقاء والآخرين في إكمال واجباتي الرياضيات على الإنترنت
						E20 الواجبات المنزلية الورقية للرياضيات لها نفس الفاعلية التي للواجبات المنزلية على الإنترنت
						E21 الواجبات المنزلية في الرياضيات على الإنترنت أفضل من الواجبات المنزلية الورقية
						E22 استخدام اللغة الإنجليزية في الرياضيات عبر الإنترنت ليست بمشكلة
						E23 أستاذي يشجعني على انجاز الواجبات المنزلية في الرياضيات على الإنترنت
						E24 تحسن الرياضيات لدي نتيجة للواجبات المنزلية عبر الإنترنت
						E25 أقضي المزيد من الوقت في اداء واجباتي المنزلية في الرياضيات على النت لأنني يمكن أن اتفاعل مع الرياضيات

Appendix 17 - Student Survey Descriptives

		N	Mean	*SD*	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
I like to do mathematics homework on the computer.	Male	124	1.31	0.48	0.043	1.22	1.39	1	3
	Female	80	1.3	0.513	0.057	1.19	1.41	1	3
	Total	204	1.3	0.492	0.034	1.24	1.37	1	3
Online mathematics homework motivates me to practice mathematics.	Male	124	1.52	0.967	0.087	1.35	1.7	1	6
	Female	80	1.54	1.006	0.112	1.31	1.76	1	6
	Total	204	1.53	0.98	0.069	1.39	1.66	1	6
I like to receive immediate scores on my mathematics homework.	Male	124	1.42	0.722	0.065	1.29	1.55	1	6
	Female	80	1.4	0.789	0.088	1.22	1.58	1	6
	Total	204	1.41	0.747	0.052	1.31	1.51	1	6
Immediate scores help me to be aware of my performance.	Male	124	1.75	1.273	0.114	1.52	1.98	1	6
	Female	80	1.65	1.092	0.122	1.41	1.89	1	6
	Total	204	1.71	1.203	0.084	1.54	1.88	1	6
I like the help and suggestions facility on my Online mathematics homework.	Male	124	1.59	1.075	0.096	1.4	1.78	1	6
	Female	80	1.88	1.236	0.138	1.6	2.15	1	6
	Total	204	1.7	1.146	0.08	1.54	1.86	1	6
I refer to the Online lesson activities to help me complete my homework.	Male	124	1.74	1.161	0.104	1.54	1.95	1	6
	Female	80	1.68	0.868	0.097	1.48	1.87	1	5
	Total	204	1.72	1.054	0.074	1.57	1.86	1	6
Online homework feedback helps me to recognise my mistakes.	Male	124	1.35	0.746	0.067	1.22	1.49	1	6
	Female	80	1.6	0.739	0.083	1.44	1.76	1	5
	Total	204	1.45	0.751	0.053	1.35	1.55	1	6
Online mathematics homework gives me more chances to practice mathematical topics.	Male	124	1.47	0.915	0.082	1.31	1.63	1	6
	Female	80	1.55	0.673	0.075	1.4	1.7	1	3
	Total	204	1.5	0.827	0.058	1.39	1.61	1	6
I enjoy doing mathematics homework activities Online more than on paper.	Male	124	1.58	1.134	0.102	1.38	1.78	1	6
	Female	80	1.73	1.102	0.123	1.48	1.97	1	6
	Total	204	1.64	1.121	0.078	1.48	1.79	1	6
The Online lesson review helps me to review mathematics concepts.	Male	124	1.49	0.95	0.085	1.32	1.66	1	5
	Female	80	1.55	0.71	0.079	1.39	1.71	1	5
	Total	204	1.51	0.862	0.06	1.4	1.63	1	5

I have less anxiety in taking Online homework than paper-based homework.	Male	124	1.72	1.116	0.1	1.52	1.92	1	6
	Female	80	1.8	1.184	0.132	1.54	2.06	1	6
	Total	204	1.75	1.141	0.08	1.59	1.91	1	6
Online mathematics homework helps me evaluate my own understanding and performance.	Male	124	1.44	0.747	0.067	1.31	1.58	1	5
	Female	80	1.63	0.832	0.093	1.44	1.81	1	5
	Total	204	1.51	0.785	0.055	1.41	1.62	1	5
I like Online mathematics homework more than paper-based mathematics homework.	Male	124	1.39	0.695	0.062	1.26	1.51	1	5
	Female	80	1.6	0.989	0.111	1.38	1.82	1	6
	Total	204	1.47	0.827	0.058	1.36	1.58	1	6
I feel I can be better at mathematics as a result of Online mathematics homework.	Male	124	1.52	0.941	0.085	1.35	1.68	1	6
	Female	80	1.71	1.203	0.135	1.44	1.98	1	6
	Total	204	1.59	1.053	0.074	1.45	1.74	1	6
I am more motivated to do my mathematics homework on the computer than on paper.	Male	123	1.46	0.771	0.07	1.33	1.6	1	5
	Female	80	1.63	1.048	0.117	1.39	1.86	1	6
	Total	203	1.53	0.892	0.063	1.4	1.65	1	6
I am easily distracted when doing Online mathematics homework.	Male	124	3.4	1.937	0.174	3.05	3.74	1	6
	Female	80	3.34	1.683	0.188	2.96	3.71	1	6
	Total	204	3.37	1.838	0.129	3.12	3.63	1	6
I discuss my Online mathematics homework with my classmates and others.	Male	124	1.8	1.269	0.114	1.57	2.02	1	6
	Female	80	1.66	0.967	0.108	1.45	1.88	1	5
	Total	204	1.75	1.159	0.081	1.59	1.91	1	6
My parents are more keen to monitor my progress in mathematics because of Online homework.	Male	124	1.68	1.335	0.12	1.44	1.91	1	6
	Female	80	1.75	0.974	0.109	1.53	1.97	1	5
	Total	204	1.71	1.204	0.084	1.54	1.87	1	6
I get help from my family, friends and others in completing my Online mathematics homework.	Male	124	1.56	0.948	0.085	1.39	1.73	1	5
	Female	80	1.85	1.115	0.125	1.6	2.1	1	5
	Total	204	1.67	1.024	0.072	1.53	1.81	1	5
Paper-based homework is just as effective as Online mathematics homework.	Male	124	1.65	1.211	0.109	1.43	1.86	1	6
	Female	80	1.93	1.167	0.13	1.67	2.18	1	6
	Total	204	1.75	1.199	0.084	1.59	1.92	1	6

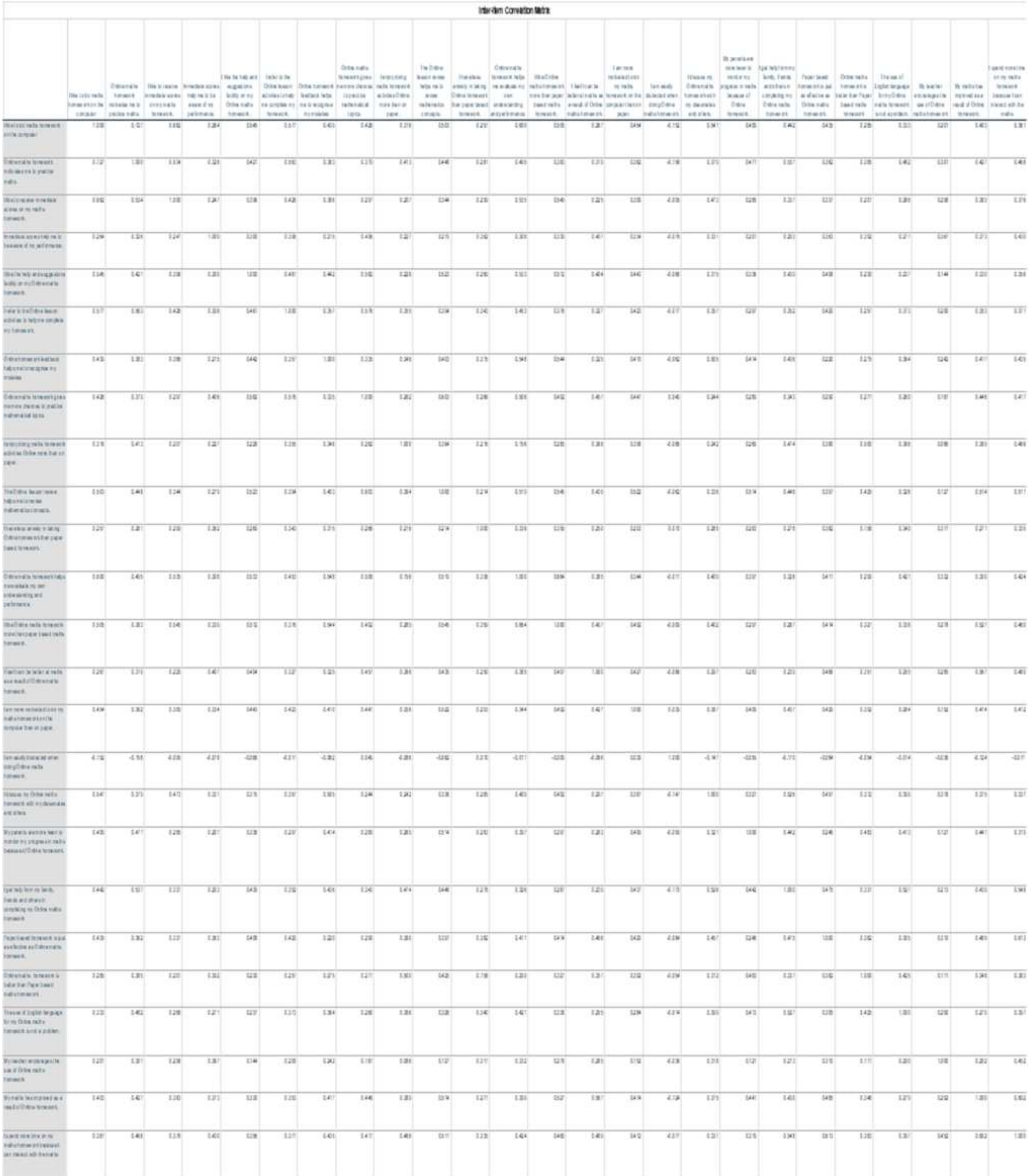
Online mathematics homework is better than Paper based mathematics homework.	Male	124	1.62	1.145	0.103	1.42	1.82	1	6
	Female	80	1.74	1.052	0.118	1.5	1.97	1	6
	Total	204	1.67	1.108	0.078	1.51	1.82	1	6
The use of English language for my Online mathematics homework is not a problem.	Male	124	1.7	1.262	0.113	1.48	1.93	1	6
	Female	80	2.08	1.394	0.156	1.76	2.39	1	5
	Total	204	1.85	1.325	0.093	1.67	2.03	1	6
My teacher encourages the use of Online mathematics homework.	Male	124	1.5	1.936	0.174	1.16	1.84	1	21
	Female	80	1.64	0.958	0.107	1.42	1.85	1	5
	Total	204	1.55	1.623	0.114	1.33	1.78	1	21
My mathematics has improved as a result of Online homework.	Male	124	1.41	0.744	0.067	1.28	1.54	1	5
	Female	80	1.55	0.81	0.091	1.37	1.73	1	6
	Total	204	1.47	0.771	0.054	1.36	1.57	1	6
I spend more time on my mathematics homework because I can interact with the mathematics.	Male	124	1.52	0.879	0.079	1.36	1.67	1	5
	Female	80	1.74	1.122	0.125	1.49	1.99	1	6
	Total	204	1.6	0.985	0.069	1.47	1.74	1	6

Appendix 18 - Test for the Assumption of Normality

	Control or intervention	Kolmogorov-Smirnova		
		Statistic	df	Sig.
Pre-test	Intervention	0.106	536	0
	Control	0.113	531	0
Post-test	Intervention	0.392	536	0
	Control	0.394	531	0

Tests of Normality							
	Control or intervention	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	Control	0.231	27	0.001	0.878	27	0.004
	Intervention	0.259	41	0	0.825	41	0
Post-test	Control	0.455	27	0	0.409	27	0
	Intervention	0.355	41	0	0.426	41	0

Appendix 19 - Inter-Item Correlation Matrix for Student Survey


Inter-Item Correlation Matrix

Appendix 20 - Item Total Statistics for Student Survey

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
I like to do maths homework on the computer	40.44	216.861	0.656	0.770	0.904
Online maths homework motivates me to practice maths.	40.21	207.217	0.653	0.709	0.901
I like to receive immediate scores on my maths homework.	40.33	214.034	0.549	0.566	0.904
Immediate scores help me to be aware of my performance.	40.03	207.405	0.512	0.437	0.904
I like the help and suggestions facility on my Online maths homework.	40.04	206.236	0.578	0.575	0.902
I refer to the Online lesson activities to help me complete my homework.	40.03	206.960	0.610	0.595	0.902
Online homework feedback helps me to recognise my mistakes	40.29	213.138	0.588	0.604	0.903
Online maths homework gives me more chances to practice mathematical topics.	40.25	211.444	0.601	0.644	0.903
I enjoy doing maths homework activities Online more than on paper.	40.10	209.400	0.491	0.520	0.904
The Online lesson review helps me to review mathematics concepts.	40.23	209.704	0.647	0.620	0.902
I have less anxiety in taking Online homework than paper-based homework.	39.99	209.762	0.470	0.349	0.905
Online maths homework helps me evaluate my own understanding and performance.	40.23	210.849	0.664	0.675	0.902

I like Online maths homework more than paper-based maths homework.	40.27	209.981	0.665	0.668	0.902
I feel I can be better at maths as a result of Online maths homework.	40.15	208.344	0.564	0.532	0.903
I am more motivated to do my maths homework on the computer than on paper.	40.22	209.775	0.622	0.499	0.902
I am easily distracted when doing Online maths homework.	38.36	228.885	-0.101	0.128	0.926
I discuss my Online maths homework with my classmates and others.	40.00	206.431	0.565	0.604	0.903
My parents are keener to monitor my progress in maths because of Online homework.	4.05	207.210	0.528	0.545	0.903
I get help from my family, friends and others in completing my Online maths homework	40.07	207.362	0.617	0.673	0.902
Paper based homework is just as effective as Online maths homework.	39.99	204.064	0.616	0.660	0.902
Online maths homework is better than Paper based maths homework	40.07	208.851	0.516	0.540	0.904
The use of English language for my Online maths homework is not a problem.	39.91	204.121	0.556	0.510	0.903
My teacher encourages the use of Online maths homework	40.19	206.163	0.382	0.387	0.909
My maths has improved as a result of Online homework.	40.28	211.488	0.647	0.646	0.902
I spend more time on my maths homework because I can interact with the maths	40.14	205.941	0.696	0.729	0.900

Appendix 21 - Student Survey Construct 1 – Item-Total Statistic

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
I like to do maths homework on the computer	11.34	23.949	.714	.710	.784
Online maths homework motivates me to practice maths.	11.11	20.790	.658	.603	.766
I like to receive immediate scores on my maths homework.	11.23	22.947	.576	.481	.784
Immediate scores help me to be aware of my performance.	10.93	21.256	.444	.249	.802
I like the help and suggestions facility on my Online maths homework.	10.94	21.001	.506	.341	.790
I enjoy doing maths homework activities Online more than on paper.	11.00	21.897	.427	.276	.802
I discuss my Online maths homework with my classmates and others.	10.90	20.812	.518	.366	.788
I spend more time on my maths homework because I can interact with the maths	11.04	21.220	.600	.415	.775

Appendix 22 - Student Survey construct 2 – Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
I refer to the Online lesson activities to help me complete my homework.	9.59	15.878	.549	.397	.762
Online homework feedback helps me to recognise my mistakes	9.86	17.610	.544	.306	.768
Online maths homework gives me more chances to practice mathematical topics.	9.81	16.983	.577	.507	.761
The Online lesson review helps me to review mathematics concepts.	9.79	16.499	.622	.514	.752
I have less anxiety in taking Online homework than paper-based homework.	9.56	16.632	.394	.183	.796
My parents are keener to monitor my progress in maths because of Online homework.	9.60	15.255	.521	.348	.771
I get help from my family, friends and others in completing my Online maths homework	9.64	16.065	.547	.324	.763

Appendix 23 - Student Survey Construct 3 – Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
I enjoy doing maths homework activities Online more than on paper.	9.25	15.466	.497	.341	.809
Online maths homework helps me evaluate my own understanding and performance.	9.37	17.235	.500	.462	.804
I like Online maths homework more than paper-based maths homework.	9.42	16.175	.639	.569	.783
I feel I can be better at maths as a result of Online maths homework.	9.30	15.081	.601	.407	.787
I am more motivated to do my maths homework on the computer than on paper.	9.36	16.084	.592	.367	.789
Online maths homework is better than Paper based maths homework	9.22	15.332	.524	.328	.803
My maths has improved as a result of Online homework.	9.42	16.513	.638	.446	.785

Appendix 24 - Rotated Component Matrix for Student Survey

Rotated Component Matrix[a]					
	Component				
	1	2	3	4	5
I feel I can be better at maths as a result of Online maths homework.	0.715				
My maths has improved as a result of Online homework.	0.653				
The Online lesson review helps me to review mathematics concepts.	0.638				
I am more motivated to do my maths homework on the computer than on paper.	0.547				
I spend more time on my maths homework because I can interact with the maths	0.521			0.497	
Online maths homework helps me evaluate my own understanding and performance.		0.694			
I like to receive immediate scores on my maths homework.		0.659			
Online homework feedback helps me to recognise my mistakes		0.641			
I like Online maths homework more than paper based maths homework.	0.551	0.593			
I like to do maths homework on the computer		0.579			0.575
I discuss my Online maths homework with my classmates and others.		0.526			
I get help from my family, friends and others in completing my Online maths homework			0.755		
I enjoy doing maths homework activities Online more than on paper.			0.679		
The use of English language for my Online maths homework is not a problem.			0.617		
My parents are more keen to monitor my progress in maths because of Online homework.			0.528		
Online maths homework motivates me to practice maths.			0.522		0.503
My teacher encourages the use of Online maths homework				0.770	
Immediate scores help me to be aware of my performance.				0.611	
I have less anxiety in taking Online homework than paper based homework.				0.531	
Paper based homework is just as effective as Online maths homework.				0.493	
I refer to the Online lesson activities to help me complete my homework.					0.748
Online maths homework gives me more chances to practice mathematical topics.	0.581				0.588
I like the help and suggestions facility on my Online maths homework.					0.527

Appendix 25 - Student interview questions

Interviews were semi-structured – not all questions were asked, or strict wording adhered to.

1. Please describe what you have open on the computer and what you have around you when studying with Myimaths out of lessons.

2. If you can remember, what influenced the changes as to how you learnt with Myimaths since you started using it (you can discuss with peers)? – metacognition
   a) I think more
   b) I revise my thinking
   c) I study by myself
   d) I use the lesson notes on the website as well as from class (students indicated that this process wouldn't happen otherwise)
   e) I am more inspired to get a better mark as the marks are displayed to all
   f) my parents can see my mark

4. What are the main differences in the way you learn maths at home using Myimaths compared to PBH? –
   a) immediacy of feedback (main highlighted difference)
   b) using the lesson notes to revise thinking (metacognition)
   c) communication - phoning peers, siblings, friends and parent involvement
   d) able to review more mathematical material
   e) better at maths

5. Using Myimaths or GeoGebra, how do you identify maths topics for improvement? –
   a) poor scores
   b) revisiting the material content
   c) incorrect construction
   d) other

6. From the survey, what were the important statements you agreed with and why?

7. The survey indicated that most students re-do or revisit their Online Homework Could you explain why? –

a) wanted maximum score, on one homework task a student indicated that they completed the homework using the next key 12 times before actually login in to record their homework score
b) syntax errors
c) the competitiveness of the group
d) marks were often publicly displayed (insensitive nature of the teacher)
e) revised thinking

8. Re-doing specific PBH questions marked incorrect with the teacher's help was not popular. Could you explain why? – response- students felt that they had:

1. forgotten about the work
2. realised their mistake
3. reproaching the teacher was unpopular – could be perceived by their peers as favouritism

PBH

1. Did you benefit from the teacher feedback?
    a) feedback was slow
    b) you often forget the work that you did
    c) You go to sleep in the class
    d) Boring
    e) only with the questions you had no idea about
2. Were you motivated in any way to do better in the post-test?
    a) not if we got full marks
    b) waste of time
    c) only if the mark improved my CA mark
    d) other reasons - explore
3. Is PBH better than WBH? (for students who had the experience of both PBH and WBH)
    a) It checks to see if you have the correct processes (multiple responses)
    b) It awards marks for the part of the answer that is correct
    c) It is cumulative
    d) It doesn't just give a right or wrong answer
    e) It's more personal – you interact with the teacher
    f) Teacher feedback if given in a timely manner can help

g) It's less impersonal – (With WBH marks are often displayed publicly to the whole class and the performance of every individual in the class is known. Also, homework scores are printed out and put up in the class – it can be embarrassing if you did well or if you did poorly)

(Adapted from Nicholls, 2010)

Appendix 26 - Examples of Coding Using NVivo

Student response	Coding	Theme
Once I am on the Internet always interacting with my friends whilst I'm doing my homework	Students BA5	Communication
We would phone each other to check on the processes used in order to get the correct answer.	Students BA3 and BA4	Communication
The instant feedback makes you check your work if there are mistakes and you can resubmit to get a better mark.	Student GA5	Instant Feedback
The instant feedback surely helped. I used my lesson notes a lot more with the WBH than with the PBH. The online lesson notes help as well and was a good way to revise.	Student GA1	Instant Feedback
Using the lesson notes to revise our thinking if we are wrong	Student BA1 and student GB2	Metacognition
Allows us to change our thinking by looking at problems again	Student GA1	Metacognition
The instant feedback makes you check your work if there are mistakes and you can resubmit to get a better mark.	Student BA5	More engagement
Instant feedback helps you to go back and check your work, especially when there are mistakes.	Students GA3	More engagement

Appendix 27 - Student Interview Transcript

Interviewees: [Schools A, B,C & D] [A-D]

Interviewer: [Sean Jenkins, Teacher A-D]

Date and Time: [mm/dd/yyyy][00:00]

Location: [UAE School A, B, C & D]

Audio file information: [Name][Duration]

27.1 Student group A (Boys A)

Question 1

Can you describe what you have opened on the computer and what you have around you when using Myimaths at home?

Students BA1

Lots of things are going on my brother is watching the TV my youngest

is that he's playing, and I'm usually eaten something.

Student BA2

I try to find a quiet place in the house so that I'm not disturbed. This is not always my room.

Students BA3

I'm in my room with some snacks and a drink, a pen and paper for notes and the Internet is open.

Student BA4

I go straight to my room and I try to get on with my homework as quickly as possible so that I can be free to spend time with my family and friends.

Students BA5

Once I am on the Internet I'm always interacting with my friends whilst I'm doing my homework.

Student BA6

I have Facebook open when I'm doing my homework.

Question 2

If you can remember, what influenced the changes as to how you learnt with Myimaths since you started using it (you can discuss with peers)?

Student BA4

I look at my class notes a lot more in addition I used to help facilities on the web site.

Student BA2

I spend more time on mathematics because I want to get full marks.

Students BA3 and BA4

I want to get full marks also so yes; we spend more time on mathematics.

Student BA1

Because the feedback is so quick if you haven't got full marks you look at your mistakes.

Student BA5

The instant feedback makes you check your work if there are mistakes and you can resubmit to get a better mark.

Student BA2

The instant feedback makes you check your work to see where you have gone wrong.

Students BA3 & BA4

Our parents can see our homework scores, and this makes me want to do better.

Student BA5

The homework marks are displayed in class for all to see and it is embarrassing if you get lower than all of your classmates.

Question 3

What are the main differences in the way you learn mathematics at home using Myimaths compared to PBH? –

Students BA3

The biggest difference is the availability of feedback straight away. This tells us if we are right or wrong. If we are wrong, we can check the work and correct it. We can straight away go to our notes, or we can use the help feature.

Student BA1

Using the lesson notes to revise our thinking if we are wrong. With the PBH, you have to wait until the teacher marks it and this can take some time. Even with the corrections made you can have forgotten the work that you did.

Students BA3 and BA4

There was more interaction with our classmates when doing the homework task. We would phone each other to check on the processes used in order to get the correct answer. This is because the answer was given to us when we checked mark it. This helps us to change our thinking.

Student BA4

I often checked the next button to find out the answers to problems I have difficulty with. I would do this fast and then try to solve.

Student BA4

My parents were more enthusiastic about me doing my homework on the computer as they could see my results straight away. This is not the case for PBH.

Student BA2

I was able to review and the practice more Mathematics content on the website Myimaths because of immediate feedback. In each homework task, I wanted to get the highest mark of100%. When my parents saw this, I was always given a gift. This motivated me to do more.

Student BA4 on behalf of all students who were in agreement:

We all have improved in Mathematics as a result of using the WBH Myimaths. This is because the use of language is easy to understand and feedback to answers you give is immediate. Sometimes you do the PBH and you never get it back.

Student BA2

WBH is more user friendly than PBH because you can access the help feature and this will take you to the Mathematics lessons where you can review a lot of material. It also allows you to practice by answering questions that gets harder and harder. This can build the confidence.

Student BA4

The most important thing for me is that I get to see the step by step process involved in order to answer the question. Even though the teacher may give this process in the lesson, it is not always clear to find. Maybe I was talking or sleeping at the time. This is because the teacher is always talking.

Question 4

Student BA5

I wanted maximum score on all homework tasks. I would keep trying until I got the best score possible.

Student BA4

Sometimes you couldn't get a maximum score because of a minor error so you have to do the whole homework task again. This was annoying at times as it took a lot of time.

Student BA1

I felt pressured from class members to do well because the homework marks were displayed in class.

Students BA3

My parents knew about the homework task and they can check my progress. They have even help me as much as a could to make sure I got full marks.

Interviewer -did you get full marks?

Students BA3

Not always. I think I got full marks on two occasions. Both were in the WBH group and once in the PBH

Question 5

Re-doing specific PBH questions marked incorrect with the teachers' feedback was not popular. Could you explain why?

Student BA2

At first the teacher mocks the work after three days. This wasn't bad because you can still remember some of the work. Later, the work was given to us after a week and we have forgotten the work we did.

Student BA4

The teacher gave the solution to the questions that were incorrect and the numbers in the second homework were not changed. If I didn't understand how would this help me?

Student BA1

I often did not understand the teacher's solution. For the PBH second task I would often use Myimaths to check the procedure.

Student BA3

My teacher only gave a right or wrong answer. The big difference was that he gave marks on the PBH tasks for partly correct answers. Myimaths didn`t do that.

Student BA5

Go to the teacher to check your work was not popular because of the people could see this as favouritism and this would make you unpopular in the class.

Question 6

Did you benefit from the PBH teacher feedback?

Student BA4

The feedback was too slow. By the time you had received it you have forgotten everything.

Student BA2

After a week the feedback is boring, and it would put you to sleep.

Student BA1

I was only interested in the questions I didn't understand. I tried hard to stay awake for these questions.

Question 7

Were you motivated in any way to do better in the post-test?

Student BA4

I was more motivate with the WBH than the PBH especially if I didn't get full marks.

Student BA2

The post-test was a waste of time if you got full marks.

Student BA5

I was interested if the mark would improve my continuous assessment mark.

Student BA1

It did help us to see if we could remember what we did the week before. I think this helps us to improve. I think this was true for both types of homework paper based, and web based.

Question 8

What is the better homework method PBH or WBH?

Student BA1

WBH checks to see if you have the correct responses to questions. If you do not, you are allowed to resubmit your homework many times. This helps you to practice a lot more than doing the homework on paper.

Student BA4

I like the help and the lesson feature. This helps me to know Mathematics a lot more.

Student BA3

Myimaths allows you to practice a lot more mathematics. This does help you to remember processes, but you only get to tick or cross for your answer. It does not give marks for the correct processes like PBH tasks.

Student BA5

PBH is more personal.

Interviewer - what you mean?

I mean you can approach the teacher to find out if you are using the correct procedure and he can tell you straight away.

Student BA2

Immediate feedback is the best thing with WBH. It encourages you to work independently by solving problems on your own.

Student BA1

Yes, I agree. Immediate feedback is a big difference between WBH and PBH. With the PBH, the feedback is given after a long time.

Student BA3

PBH is less impersonal. The marks are not displayed in the class and if you have issues you can see the teacher.

27.2 Student group B (Boys B)

Question 1

Can you describe what you have opened on the computer and what you have around you when using Myimaths at home?

Students BB1

I'm often on the phone to my friend in the class who can help me if I need it. We share answers and we learn together.

Student BB2

My older brother likes the website and practices his math on it, so I get a lot of help from him as he's good at math. Computer games are always being played on the computer and we play together.

Students BB3

I have Facebook and computer games open on my computer

Student BB4

Only my homework is on the computer and once I've finished, I may browse other sites

Students BB5

I'm on the Internet and I always interact with my friends whilst I'm doing my homework. Play games mostly.

Student BB6

I have Facebook open when I'm doing my homework.

Question 2

If you can remember, what influenced the changes as to how you learnt with Myimaths since you started using it (you can discuss with peers).

Student BB4

I am more motivated to go to the site and look at notes and to use help features. I practice and interact with a lot more math material than before. It has some good games too.

Student BB2

I spend more time on mathematics because I want to get full marks as I compete with my friends. We communicate more about homework, so I think it gives us more interest.

Student BB3

I want to get full marks too, so I spend more time on the math.

Student BB1

The feedback is instant so if you haven't got full marks you look at your mistakes. This makes you practice more and understand the math.

Student BB5

The instant feedback helps you to check your work if there are mistakes and you can resubmit to get a better mark. Many students involved in the study didn't like being limited to two submissions. There was an easy way around it.

Interviewer – What was that?

Student BB5

Just click the next button without entering your login information. This way, you can do the task as many times as you like to make sure you understand what is required.

Student BB2

The instant feedback makes you check your work to see where you have gone wrong. This made you spend more time on math homework. Not good.

Students BB1 & BB4

Our parents could access our homework scores, and this made us have to perform better.

Student BB5

The homework marks are displayed in class for all to see and it is embarrassing if you get lower than all of your classmates.

Question 3

What are the main differences in the way you learn mathematics at home using Myimaths compared to PBH? –

Students BB3

The availability of instant feedback. Even though it just gives a right or wrong answer.

Student BB1

You can't just work on the computer; you have to work out the solutions on paper first before you enter any steps or give the answer. With 27 students in the class, the PBH takes the teacher a long time to mark. When the feedback come, we have forgotten the math. This happened to me when I did the post-test.

Students BB3 and BB4

There was more interaction with our classmates when doing the homework task. We would phone each other to check on the processes used in order to get the correct answer. This is because the answer was given to us when we checked mark it. This helps us to change our thinking.

Student BB5

I could easily find out the answers to problems by using the "Mark it" button. I would do this first and then try to work out the problems from the answers.

Interviewer: so, you used a trial and error type approach to solve the homework problems?

Students BB2

Yes. I clicked the Next button so that you wouldn't know my login details and how many times I attempted the homework task. This helped me to get very good scores not just in the homework, but in my end of year exams too. I practiced a lot.

Student BB5

My parents were very happy about me doing homework on the computer. They were just happy to see me doing math homework as they didn't see me doing much math homework before. I got a lot of gifts from them as a result of this. This encouraged me to do more and I got good math scores.

Student BB2

Instant feedback helped me to practice more math and to get better marks. Not just in the homework tasks but in the tests also. I competed with my peers to get the best mark possible and even though that wasn't always the case, I did well.

Interviewer: Was language a problem on some homework tasks?

Student BB1

The language was more of a problem with the PBH. With the WBH you could always check your problems again. This allows you to constantly check your thinking and your methods used.

Student BB2

WBH is better than PBH because you can use the help feature to take you to the Mathematics lessons where you can review a lot of material. It also allows you to practice by answering questions that gets harder and harder. This can build the confidence.

Student BB4

The most important thing for me is that I get to see the step by step process involved in order to answer the question. Even though the teacher may give this process in the lesson, it is not always clear to find. Maybe I was talking or sleeping at the time. This is because the teacher is always talking.

Question 4

The survey indicated that most students re-do or revisit their Online Homework Could you explain why? –

Student BB1

Maximum score on all homework tasks. We would keep trying until we got the best score possible.

Interviewer: Are you speaking for yourself or for everyone here?

Student BB1

I'm speaking for all. Do you agree?

All students

Replied with yes or shook heads

Student BB5

Sometimes it's not always possible to get a maximum score because of a mistake with the system. This was annoying at times as it took a lot of time to get the question right and the mistake was minor. It could be a misplaced decimal or a rounding error.

Student BB1

I felt pressured from class members to do well because the homework marks were displayed in class.

Student BB3

My parents knew about the homework task and they always checked my progress. I will not complain because they were helpful.

Interviewer - did you get full marks?

Student BB3

Often. I got full marks regularly. I got full marks on both the PBH and the WBH. Having knowledge of WBH did help me with the PBH.

Question 5

Re-doing specific PBH questions marked incorrect with the teachers' feedback was not popular. Could you explain why?

Student BB2

The teacher took too long to mark the work. When the couple were back you couldn't remember it. Automatically, you switch off when he reviews it in class.

Student BB5

The teacher gave the solution to the questions that were incorrect and the numbers in the second homework were not changed. If I didn't understand how would this help me?

Student BB1

I couldn't understand the teachers' writing. I must ask him and then sometimes I still don't understand. With the PBH second task I would often use Myimaths to check the procedure.

Interviewer – Why did you use Myimaths to solve your PBH?

Student BB1

To get the best mark possible. I know it may cause problems with the research, but we must get good marks. I did it more with the GeoGebra homework because I could see what the graph looked like very easily without having to plot points myself. This was good and necessary to save time.

Student BB2

My teacher marked the paper thoroughly. He gave marks for the steps used and not just the final answer. This is the big difference between PBH and the WBH. With the WBH if I get part of the answer correct, I'm not given any marks.

Student BB4

After I get the mark for my PBH task my teacher is unapproachable, and the feedback given to me is final. That is the end of the matter.

Question 6

Did you benefit from the PBH teacher feedback?

Student BB4

The feedback is slow in comparison to WBH. By the time you had received it you have forgotten everything.

Student BB2

In some cases, it's helpful but the majority of the time is boring, and it would put you to sleep.

Student BB1

To get feedback on work that you didn't understand is helpful. To get feedback on work that you understand after a week is a waste of time.

Question 7

Were you motivated in any way to do better in the post-test?

Student BB3

I was more motivate with the WBH than the PBH especially if I didn't get full marks.

Student BB1

The post-test was a waste of time if you got full marks.

Student BB4

I was only thinking of my continuous assessment mark and to make a good impression with the teacher.

Student BB2

The post-test helps us to see if we could remember what we did before. This was good with the WBH as the numbers were different. With the PBH, it wasn't that much of a challenge because it was the same homework task.

Question 8

What is the better homework method PBH or WBH?

Student BB1

WBH is better because it encourages you to think more and to work independently. The problem is it doesn't award marks for correct steps when you have the wrong answer. When the teacher marks PBH he gives these marks.

Student BB4

I like the lesson feature. I learnt a lot of mathematics from this.

Student BB5

WBH helps you to practice more Math because it is interactive, and the feedback is instant. Because the feedback is instant the time spent on math homework is of better quality.

Student BB3

With the PBH your mark is not displayed in the class and there is less embarrassment as the feedback is personal. If you want to follow up with the teacher after you can.

Student BB2

Immediate feedback is the best thing with WBH. It encourages you to work independently by solving problems on your own.

Student BB1

Yes, I agree. Immediate feedback is a big difference between WBH and PBH. With the PBH, the feedback is given after a long time and we don't really pay any attention to it. I never correct my mistakes or give it much though. I just look at the score to see if it is ok or not.

Student BB5

I agree with student C; PBH is less impersonal. The marks are not displayed in the class and if you have any problems you can see the teacher.

27.3 Student group C (Girls A)

Question 1

Can describe what you have opened on the computer and what you have around you when using Myimaths at home?

Students GA1

My older sister is always using social media, so these apps are often opened on the computer. We share the same room and computer. She's good because she always allows me to do my homework and she even helps me sometimes. She also practices for Math on the computer.

Student GA2

I am disturbed a lot at home, and I have to find a quiet place to my homework. I like to take snacks and a drink to my room and I also might have the TV on. I am constantly in contact with my friends on the phone.

Students GA3

I like to have snacks in my room as well. I have my own room and my own computer, and I'm not distracted but I do have my phone with me always.

Student GA4

When I'm doing my math homework, my phone is connected to my computer because it needs charge. I'm always using what's App and Messenger and yes, it is distracting sometimes.

Students GA5

Once I am on the Internet I'm always interacting with my friends whilst I'm doing my homework.

Student GA6

I have Facebook open when I'm doing my homework and my TV is on.

Question 2

If you can remember, what influenced the changes as to how you learnt with Myimaths since you started using it (you can discuss with peers)?

Student GA4

I communicate a lot more with my classmates. We talk about the homework and we share strategies. This never happened before, and it makes learning more fun.

Student GA2

I think that that getting full marks is a goal for all of us and we try to work together to achieve this. This is not a bad thing it is a good thing; I think.

Student GA3

Instant feedback helps you to revise your thinking and you can share this with others. I think the sharing part this helps make math more understandable.

Students GA3 and GA4

We want to get full marks also so yes; we spend a lot more time doing math homework.

Student GA1

The instant feedback helps you to go back and check your work, especially when there are mistakes. Because you want to get full marks it makes you want to repeat the homework task again.

Student GA5

The instant feedback makes you check your work if there are mistakes and you can resubmit to get a better mark.

Student GA6

The instant feedback makes you check your work to see where you have gone wrong.

Students GA4

My parents like the idea of what based homework as they can monitor my progress in math. They also feel that I'm doing more math homework.

Student GA5

The homework marks are displayed in class for all to see and it is embarrassing if you get lower than all of your classmates. I think this helped us decide to work together a lot more.

Question 3

What are the main differences in the way you learn mathematics at home using Myimaths compared to PBH? –

Students GA3

The availability of instant feedback and the way in which I communicate with my classmates. We looking to do well.

Student GA1

The instant feedback surely helped. I used my lesson notes a lot more with the WBH than with the PBH. The Online lesson notes help as well and was a good way to revise.

Students GA3 and GA6

There was more interaction with our classmates when doing the homework task. We would phone each other to check the processes used in order to get the answer correct. The communication helped with thinking. For example, after completing a question, my friend told me how to check it without having to start the whole login process again. This way, you couldn't see how many times I completed the task. I think it's a good thing to be allowed multiple submissions.

Student GA4

I often checked the next button too, to find out the answers to problems I have difficulty with. I would do this first before login in and then try to solve.

Student GA5

Instant feedback and the mark score was the key. My parents were very impressed with this and that encouraged me to do more math homework. The GeoGebra homework was fun and enjoyable too. I understand graphs and their functions and transformations a lot more from GeoGebra. This is not the case for PBH.

Student GA4

The GeoGebra homework was engaging and fun to do. I understood circle calculations and their transformations a lot more using GeoGebra. This was not the case when given PBH. Using GeoGebra made the circle equations a lot clearer and easier to understand.

Student GA2

I could revise and practice more Math content on the website Myimaths because of immediate feedback. In each homework task, I wanted to get the highest mark of 100%. When my parents saw this, they were always impressed. This helped to motivate me to do more mathematics tasks on the computer.

Student GA6 on behalf of all students who were in agreement:

I found the language easier on the computer than on the paper. It took time to get used to both once you understand how the website worked it was a good benefit. It helps me to improve my math more than the work given to me on paper. You still have to use paper to solve problems before entering the answer.

Student B

WBH is more user friendly than PBH because you can access the help feature and this will take you to the Mathematics lessons where you can review a lot of material. It also allows you to practice by answering questions that gets harder and harder. This can build the self-confidence.

Student GA4

Being able to look at the lesson review to see how problems are worked out step by step is of great value. It is as if you have a teacher that is helping you to work by yourself, sorry independently. PBH does not encourage this process easily. I mean, it is more difficult to do.

Question 4

The survey indicated that most students re-do or revisit their Online Homework Could you explain why? –

Student GA5

Isn't it obvious? It is to get the best score possible.

Student GA4

Sometimes it was an easy to get 100% because of a computer error or should I say an error with the programme that was often minor. It was a pain because you ended up spending a lot of time trying to correct something that was impossible to correct.

Student GA1

It was important that everybody in the class got high marks otherwise you would feel embarrassed. Nobody wanted the lowest mark. This is for sure.

Students GA6

My parents always wanted me to get full marks and they can check my results. They have access to my username and password and my login details. They saw me doing more Online math homework than the homework given on paper.

Interviewer -did you get full marks?

Students GA3

Not all the time but my homework marks were high especially in the WBH post-test. The teacher did set homework tasks outside of the experiment and I did get 100% in those.

Question 5

Re-doing specific PBH questions marked incorrect with the teachers' feedback was not popular. Could you explain why?

Student GA2

The teacher often takes too long to give the feedback. When she gives the feedback, we have forgotten the work or it's too boring to go through.

Student GA4

It's not too boring you going to learn something about the questions you have difficulty with. Especially if it is a question that will be in the examination or the tests. This would help focus your attention.

Student GA1

If the teacher didn't explain the solutions to the problems, you had difficulty with, and we don't follow up by asking the teacher then the feedback is of no benefit. This is our mistake because we should've asked the teacher, but we don't.

Student GA3

I like the PBH feedback because the teacher gives marks for the parts to the question and even if you answer is wrong because the marks for the process. This is better than the

Question 6

Did you benefit from the PBH teacher feedback?

Student GA4

The feedback was too slow. By the time you had received it you have forgotten everything.

Student GA5

The teacher took far too long to mark the work by which time the feedback given is of no benefit.

Student GA1

I was only interested in the questions I didn't understand.

Student GA3

I was interested in the feedback given if some of the questions or processes were going to be in the test.

Question 7

Were you motivated in any way to do better in the post-test?

Student GA4

I was more motivated with the WBH than the PBH especially if I didn't get full marks.

Student GA2

I didn't understand the point of the post-test if you got full marks the first time around, especially with the PBH. At least with the WBH the numbers were different.

Student GA5

I was only interested if the mark would improve my continuous assessment mark. I was one of the students who didn't bother with the post-test towards the end.

Student GA1

We had the chance to reflect on what work we did in class recently. This helped us to improve at math and remember what we did. I think for sure the WBH made us practice and prepare for our tests a lot more. It also encouraged independent learning.

Question 8

What is the better homework method PBH or WBH?

Student GA1

WBH gives you immediate feedback and allows us to change our thinking by looking at problems again. This helps us to practice more math which is a good thing. PBH is still good but it doesn't encourage you to look at math in the way that WBH does.

Student GA6

I like the help and the lesson feature. This helps me to practice math a lot more. It also helps me to work independently without support. My report said that I needed less support from the teacher in math.

Student GA3

WBH allows you to practice a lot more math. I communicate a lot more with my friends and classmates in order to finish the homework. I now do more homework in math because of the WBH. Therefore, I must enjoy it more than the PBH.

Student GA5

PBH is marked more thoroughly than WBH.

Interviewer - what you mean?

Student GA5

I mean you get marks for all the question and not just the answer. Some questions have more than 2 or 3 steps and with the WBH you don't enter or see the marks for that.

Student GA2

Immediate feedback tells me to check my work or to change my thinking if I have the wrong answer. If I have the wrong answer with the PBH I'm sure I wouldn't check it when given the paper back. I would just look at my mark.

Student GA4

She's right. I'm sure that most of us would just look at the score and not bother to look at the teacher's comments or the marking to see where or how we had made the mistakes. This is the big difference between WBH and PBH.

Student GA1

The PBH marks are not put up to be displayed to all but the WBH marks are and this is a problem. Nobody like to be embarrassed.

2.7.4 Student group D (Girls B)

Question 1

Can describe what you have opened on the computer and what you have around you when using Myimaths at home?

Students GB1

I am always using social media. I have my own room, so I can communicate with who I like. I often talk to my friends and colleagues.

Student GB2

I like to take snacks and a drink to my room and I also might have the TV on. I am constantly in contact with my friends on the phone.

Students GB3

I have my own room and my own computer, and I'm not distracted but I do have my phone with me always. The TV is on and sometimes I listen to music.

Student GB4

When I'm doing my math homework my I'm always using What's App and Messenger and yes, it is distracting.

Students GB5

Once I am on the Internet I'm always interacting with my friends even when I'm doing my homework.

Student GB6

Facebook is open when I'm doing my homework and my TV is on.

Question 2

If you can remember, what influenced the changes as to how you learnt with Myimaths since you started using it (you can discuss with peers)?

Student GB4

Instant feedback made me spend a lot more time on my homework. I started to work independently on mathematics and even developed critical thinking.

Interviewer: How did you develop critical thing?

Student GB4

I started thinking about the mistakes and correct them. And this wouldn't have happened was PBH.

Student GB2

The amount of time and now spend it doing math is much more than before. The strange thing is that I actually enjoy doing it. I communicate a lot more with my classmates and this didn't happen before.

Students GB3 and GB5

I resubmitted one homework task maybe 12 times just to try to get full marks. Even when we as when we were asked to limit this to two submissions I continued to benefit from multiple submission. I didn't care.

Student GB6

Because the feedback is so quick if you haven't got full marks you look at your mistakes.

Student GB5

The instant feedback makes you check your work if there are mistakes and you can resubmit to get a better mark. I resubmitted a lot even though we were told to limit our submissions to two. I ignored this for both the Myimaths and the GeoGebra homework.

Student GB1

Because the feedback is so quick you able to revise your work and resubmit many times. This will help you to get the best mark possible. As long as you can do this in the time that you are given there is no problem. You also benefit greatly from the additional practice.

Students GB4 & GB5

My parents were really impressed with me doing homework on a regular basis. When they could see what I was doing in math and the marks I was getting this impressed them further.

Question 3

What are the main differences in the way you learn mathematics at home using WBH compared to PBH? –

Students GB5

The biggest difference is the availability of feedback straight away. This tells us if we are right or wrong. If we are wrong, we can check the work and correct it. We can straight away go to our notes, or we can use the help feature.

Student GB2

Using the lesson notes to revise our thinking if we are wrong. With the PBH, you have to wait until the teacher marks it and this can take some time. Even with the corrections made you can have forgotten the work that you did.

Students GB1 and GB4

There was more interaction with our classmates when doing the homework task. We would phone each other to check on the processes used in order to get the correct answer. This is because the answer was given to us when we checked mark it. This helps us to change our thinking.

Student GB3

I often checked the next button to find out the answers to problems I have difficulty with. I would do this fast and then try to solve.

Student GB5

My parents were more enthusiastic about me doing my homework on the computer as they could see my results straight away. This is not the case for PBH.

Student GB2

I was able to review and the practice more Mathematics content on the website Myimaths because of immediate feedback. In each homework task, I wanted to get the highest mark of100%. When my parents saw this, I was always given a gift. This motivated me to do more.

Student GB4

We all have improved in Mathematics as a result of using the WBH Myimaths. This is because the use of language is easy to understand and feedback to answers you give is immediate. Sometimes you do the PBH and you never get it back.

Student GB6

With the WBH you have the tool feature as a strong support. The lesson button can take you back over the work that you did in class. It is extremely helpful in building confidence and making you practice math with understanding because the questions get harder as you get a better.

Student GB1

The language of the WBH is easy to understand and because you can constantly review it, you can get better. The step by step process helps you to build confidence. Also, because the information is always there you can review it at any time. With your PBH, the information is not always clear to find.

Question 4

The survey indicated that most students re-do or revisit their Online Homework Could you explain why? –

Student GB3

I wanted maximum score on all homework tasks. I would keep trying until I got the best score possible.

Student GB5

It wasn't always possible to get 100% because of a minor mistake and a horrible thing was that you have to do the homework again. This took a lot of time

Student GB1

I wanted to be the best in the class and get full if marks for all homework tasks WBH or PBH, I didn't care.

Students GB3

I think all of us set out to get full marks as the homework on the computer was impressive. When we were told that it would support our continuous assessment mark, we all tried our best, of course.

Interviewer -did you get full marks?

Students GB5

Not always. Sometimes, but my continuous assessment mark was very good. I was happy.

Question 5

Re-doing specific PBH questions marked incorrect with the teachers' feedback was not popular. Could you explain why?

Student GB3

If the teacher took a long time to mark the work the information was lost.

Student GB4

In the post-test I resubmitted the same work I did in the pre-test because I found it very difficult to do exactly the same test again after a week. Especially, when I received a good mark.

Student GB2

Yes, I agree with the student GB4. I did the same in resubmit the same PBH in the post-test because I couldn't understand the corrections my teacher made. I did try to correct it but ended up making another mistake. I did get a better mark.

Student GB3

My teacher gave a right or wrong answer. The big difference was that she gave marks on the PBH tasks for partly correct answers. Myimaths didn`t do that.

Student GB5

If some students are honest, they would admit to using the WBH tool to answer the PBH questions.

Question 6

Did you benefit from the PBH teacher feedback?

Student GB4

The feedback was too slow if you are comparing it with the WBH. The WBH is for sure better group with giving the feedback because it is immediate.

Student GB6

By the time you get the PBH all the information learnt in the class has gone. How to remember?

Student GB1

I was only interested in the questions I didn't understand

Question 7

Were you motivated in any way to do better in the post-test?

Student GB2

The post-test was didn't make a lot of sense if you got full marks. At least with the WBH the numbers were different.

Student GB4

I think we were all better motivated with the WBH than with the PBH.

Student GB5

I was always interested and motivated because I wanted to improve my continuous assessment mark.

Student GB1

The post-test process was good because it helps us remember what we did in the class the week before. With the WBH we were encouraged to repeat the processes used again and again to build confidence.

Question 8

What is the better homework method PBH or WBH?

Student GB6

WBH checks to see if you have the correct responses to questions. If you do not, you are allowed to resubmit your homework many times. This helps you to practice a lot more than doing the homework on paper.

Student GB4

I like the help and the lesson feature. This helps me to know Mathematics a lot more. I found that when I was stuck, absent or not focussed in lessons, I could review the same material that was taught in the class at home. This helped me a great deal as I could learn and think at my own pace.

Student GB3

WBH encouraged you to communicate a lot more with your peers and this support helped you to understand math more.

Interviewer: What do you mean by understanding math more?

Students GB3 and GB1

We were able to review and revise the math again and again to make sure that we had or were using the correct processes. Once we had got it, we shared information. We practiced doing math a lot more with the WBH than with the PBH.

Student GB5

PBH is more personal. The teacher can see your thought processes and give you marks for it even if your answer is wrong. With the WBH that isn't the case. You can spend a long time answering the question like in the differentiation and you don't get any marks for your working.

Interviewer – was the feedback given in a timely manner?

Student GB5

If you care about the work the feedback is still fresh after a few days. If it is longer than that and other things like homework activities or changes outside of school have happened, it is far less important and then you don't care. It depends on your mind at the time.

Student GB2

Immediate feedback is the best thing with WBH. It encourages you to work independently by solving problems on your own. It makes you think a lot more about the math than PBH.

Student GB1

I agree. Immediate feedback is the big difference between WBH and PBH. With the PBH, the feedback is given after a long time and as student E said earlier, maybe too many things have passed in the time that you completed the homework and the time that you've received it.

Student GB3

PBH is less impersonal. The marks are not displayed in the class and if you have issues you can see the teacher.

Appendix 28 - Letter of Informed Consent

Principal Investigator:

Sean Jenkins
Abu Dhabi Education Council
School Operations
Tel: +971567723254
sean.jenkins@adec.ac.ae

Background

You are being invited to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. Please ask the researcher anything that you feel is not clear or if you need more information.

The purpose of this study is: to compare Web-based homework with Paper-based homework

Study Procedure

Student participants will need to complete a survey in their classes. The expected duration of the survey is 20 minutes.

Student participants will need to complete homework tasks associated with their school learning. Some participants will complete their homework on the computer whilst others will be given their homework on paper/worksheet.

Risks

The risks in this study are minimal. Some participants may be upset at not being involved in the Web-based homework experimental group. Participants are reminded that they may decline to answer any questions on the survey or homework tasks. They may also choose to terminate their participation in the research at any time.

Benefits

Your participation will bring about considerable research knowledge and understanding about the methods of homework given in this study. It is hoped that the research findings will benefit the knowledge base associated with Web-based homework and Paper-based homework and inspire further research.

Confidentiality

Please do not write any identifying information on your survey. Your responses will be anonymous. I will be the only person that will have access to the information provided and this information will not be shared with anyone. Where references are made to the school or students', pseudonyms will be used.

Every effort will be made by the researcher to preserve your confidentiality including the following:

Assigning code names/numbers for participants that will be used on all researcher notes and documents.

• Notes, interview transcriptions, and transcribed notes and any other identifying participant information will be kept in a locked file cabinet in the personal possession of the researcher. When no longer necessary for research, all materials will be destroyed.

• The researcher and the members of the researcher's committee will review the researcher's collected data. Information from this research will be used solely for the purpose of this study and any publications that may result from this study. Any final publication will contain the names of the public figures that have consented to participate in this study (unless a public figure participant has requested anonymity): all other participants involved in this study will not be identified and their anonymity will be maintained

• Each participant can obtain a transcribed copy of their interview if they so wish.
The participants should tell the researcher if a copy of the interview is desired.

Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents. These incidents include, but may not be limited to, incidents of abuse and suicide risk.

Voluntary Participation

It is important to understand that your participation in this study is voluntary. It is entirely up to you to decide whether or not to take part in this study. If you do decide to take part in this study, you will be asked to sign a consent form. If you decide to take part in this study, you are still free to withdraw at any time and without giving a reason. You are free to not answer any question or questions if you choose. This will not affect the relationship you have with the researcher.

Costs

There are no costs to you for your participation in this study

Compensation

There is no monetary compensation to you for your participation in this study.

Contact

Should you have any questions about the research or any related matters, please contact the researcher at:

sean.jenkins@adec.ac.ae
Tel: +971567723254

Consent

By signing this consent form, I confirm that I have read and understood the information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Signature ____ Date ____________________

Appendix 29 - Pattern Matrix using Promax Rotation

Pattern Matrix[a]

	Component			
	1	2	3	4
I like to do maths homework on the computer	0.794			
Online maths homework motivates me to practice maths.	0.615			
I like to receive immediate scores on my maths homework.	0.784			
Immediate scores help me to be aware of my performance.				0.601
I like the help and suggestions facility on my Online maths homework.		0.680		
I refer to the Online lesson activities to help me complete my homework.				
Online homework feedback helps me to recognise my mistakes	0.442			
Online maths homework gives me more chances to practice mathematical topics.		0.905		
I enjoy doing maths homework activities Online more than on paper.			0.845	
The Online lesson review helps me to review mathematics concepts.		0.684		
I have less anxiety in taking Online homework than paper based homework.				0.526
Online maths homework helps me evaluate my own understanding and performance.	0.537	0.503		
I like Online maths homework more than paper based maths homework.		0.625		
I feel I can be better at maths as a result of Online maths homework.		0.608		
I am more motivated to do my maths homework on the computer than on paper.		0.438	0.402	
I discuss my Online maths homework with my classmates and others.	0.591			
My parents are more keen to monitor my progress in maths because of Online homework.			0.474	
I get help from my family, friends and others in completing my Online maths homework			0.757	
Paper based homework is just as effective as Online maths homework.				0.449
My teacher encourages the use of Online maths homework				0.884
My maths has improved as a result of Online homework.			0.424	
I spend more time on my maths homework because I can interact with the maths			0.478	0.477

Extraction Method: Principal Component Analysis.
a. Rotation converged in 9 iterations.

Appendix 30 – Feedback Characteristics and Learning Theories

M. Thurlings et al. / Educational Research Review 9 (2013) 1–15 5

Table 1
Overview of feedback characteristics.

Characteristic	Behaviourism	Cognitivism	Social cultural theory	Meta cognitivism	Social constructivism
Corrective; GAS; PAS	x	x			
KCR feedback		x	x		x
Elaborative feedback before KCR		x	x		x
Direct or indirect corrective feedback		x			
Interactional feedback		x			
Identifying and correcting errors			x		
Explaining misunderstandings			x		
Specific	x	x	x		x
Clear		x			
Concrete			x		
Consistent			x		
Descriptive					x
Directive	x		x		
Explicit or implicit		x			
Polite or direct			x		
Positive or negative		x			
Positive	x		x		x
Unbiased, objective		x			
Neutral		x			x
Non judgmental, non hurtful					x
Non evaluative					x
Balanced between positive and negative			x		x
Balanced with grade			x		x
Based on actual data					x
Summative and formative			x		x
Formative			x		
Accurate, irrefutable			x		x
Relevant, meaningful			x		x
Justifying marks			x		
Justification					x
Instructional (Parallel, expansive, novel)	x				
Performance feedback	x				
Form and content		x			
Product and process		x			
Leaving control to learner				x	
Sufficient					x
Constructive					x
Challenging					x
Consequence of performance					x

Appendix 31 – Student Survey Inter Item Correlation Matrix

Spearman's rho		Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Item 14	Item 15	Item 16	Item 17	Item 18	Item 19	Item 20	Item 21	Item 22	Item 23	Item 24	Item 25
Item 1	Corr.	1.000	.872**	.693**	.408**	.639**	.624**	.352**	.464**	.341**	.533**	.354**	.596**	.456**	.418**	.584**	-.159*	.583**	.524**	.585**	.544**	.376**	.464**	.523**	.418**	.476**
	Sig.		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.023	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 2	Corr.		1.000	.644**	.508**	.574**	.612**	.400**	.531**	.379**	.549**	.426**	.584**	.468**	.475**	.519**	-.175*	.547**	.556**	.664**	.557**	.402**	.516**	.541**	.506**	.570**
	Sig.			.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.013	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 3	Corr.			1.000	.443**	.560**	.539**	.332**	.449**	.335**	.422**	.432**	.583**	.568**	.484**	.465**	-.126	.544**	.441**	.542**	.506**	.313**	.439**	.511**	.455**	.484**
	Sig.				.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.073	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 4	Corr.				1.000	.410**	.463**	.402**	.522**	.269**	.436**	.496**	.489**	.556**	.554**	.476**	-.100	.527**	.384**	.432**	.386**	.429**	.382**	.484**	.577**	.471**
	Sig.					.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.157	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 5	Corr.					1.000	.580**	.463**	.565**	.361**	.490**	.423**	.587**	.576**	.494**	.513**	-.106	.439**	.474**	.534**	.524**	.339**	.420**	.475**	.355**	.416**
	Sig.						.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.132	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 6	Corr.						1.000	.361**	.577**	.446**	.545**	.416**	.565**	.529**	.545**	.534**	-.075	.495**	.433**	.520**	.552**	.371**	.528**	.398**	.394**	.524**
	Sig.							.000	.000	.000	.000	.000	.000	.000	.000	.000	.285	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 7	Corr.							1.000	.484**	.443**	.508**	.492**	.442**	.518**	.443**	.408**	-.099	.424**	.452**	.452**	.318**	.360**	.441**	.402**	.470**	.456**
	Sig.								.000	.000	.000	.000	.000	.000	.000	.000	.161	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 8	Corr.								1.000	.437**	.700**	.523**	.619**	.619**	.662**	.486**	.026	.424**	.492**	.482**	.457**	.342**	.519**	.411**	.499**	.625**
	Sig.									.000	.000	.000	.000	.000	.000	.000	.714	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Corr.									1.000	.412**	.440**	.267**	.446**	.433**	.352**	-.105	.347**	.325**	.458**	.400**	.489**	.432**	.265**	.371**	.570**

Item 9	Sig.	.000	.000	.000	.000	.000	.000	.137	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 10	Corr.	1.000	.389**	.617**	.607**	.588**	.553**	-.095	.437**	.476**	.574**	.441**	.393**	.489**	.453**	.588**	.622**
	Sig.		.000	.000	.000	.000	.000	.177	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 11	Corr.		1.000	.423**	.565**	.482**	.413**	-.041	.409**	.448**	.489**	.451**	.277**	.448**	.325**	.452**	.483**
	Sig.			.000	.000	.000	.000	.561	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 12	Corr.			1.000	.692**	.578**	.483**	-.046	.472**	.505**	.484**	.498**	.350**	.524**	.507**	.436**	.507**
	Sig.				.000	.000	.000	.509	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 13	Corr.				1.000	.717**	.507**	-.055	.458**	.373**	.475**	.501**	.388**	.457**	.530**	.541**	.590**
	Sig.					.000	.000	.435	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 14	Corr.					1.000	.455**	-.071	.475**	.361**	.431**	.540**	.402**	.478**	.493**	.464**	.616**
	Sig.						.000	.314	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 15	Corr.						1.000	.031	.509**	.509**	.611**	.541**	.495**	.556**	.439**	.580**	.517**
	Sig.							.661	.000	.000	.000	.000	.000	.000	.000	.000	.000
Item 16.	Corr.							1.000	-.178*	-.168*	-.119	-.124	-.118	-.056	-.195**	-.107	-.078
	Sig.								.011	.016	.090	.078	.094	.426	.005	.128	.266
Item 17	Corr.								1.000	.489**	.664**	.623**	.428**	.546**	.606**	.484**	.507**
	Sig.									.000	.000	.000	.000	.000	.000	.000	.000
Item 18	Corr.									1.000	.666**	.491**	.532**	.609**	.442**	.555**	.455**
	Sig.										.000	.000	.000	.000	.000	.000	.000

Item 19	Corr.	1.000	.696**	.552**	.694**	.592**	.611**	.705**
	Sig.		.000	.000	.000	.000	.000	.000
Item 20	Corr.		1.000	.521**	.537**	.558**	.473**	.658**
	Sig.			.000	.000	.000	.000	.000
Item 21	Corr.			1.000	.567**	.404**	.425**	.491**
	Sig.				.000	.000	.000	.000
Item 22	Corr.				1.000	.464**	.514**	.561**
	Sig.					.000	.000	.000
Item 23	Corr.					1.000	.653**	.533**
	Sig.						.000	.000
Item 24	Corr.						1.000	.676**
	Sig.							.000
Item 25	Corr.							1.000
	Sig.							

*Note: *** p<.001, ** p<.01, * p<.05*

Appendix 32 - Survey Item Frequencies (N= 204)

		Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree		Don't Know		Mean
	Survey Items	%	N	%	N	%	N	%	N	%	N	%	N	
E1	I like to do maths homework on the computer.	71.1	156	27.5	56	1.5	3							1.31
E2	online maths homework motivates me to practice maths.	65.7	134	25.0	51	5.41	11	0.5	1	1.5	3	4	2	1.53
E3	I like to receive immediate scores on my maths homework.	68	139	26	53	4.4	9	0.5	1			1	2	1.41
E4	Immediate scores help me to be aware of my performance.	59.3	121	27	55	7.4	15	0.5	1	1.5	3	4.4	9	1.71
E5	I like the help and suggestions facility on my online maths homework.	61.3	125	22.1	45	8.8	18	2.9	6	2.9	6	2	4	1.7
E6	I refer to the online lesson activities to help me complete my homework.	57.4	117	24.5	50	11.8	24	2.9	6	2.5	5	1	2	1.71
E7	Online homework feedback helps me to recognise my mistakes.	64.2	131	30.4	62	3.4	7	0.5	1	1	2	0.5	1	1.45
E8	Online maths homework gives me more chances to practice mathematical topics.	63.7	130	27	55	7.4	15	0.5	1	0.5	1	1	2	1.5
E9	I enjoy doing maths homework activities online more than on paper.	65.7	134	19.6	4	5.9	12	3.9	8	3.9	8	1	2	1.64
E10	The online lesson review helps me to review mathematics concepts.	64.7	132	25	51	6.9	14	1	2	2.5	5			1.51
E11	I have less anxiety in taking online homework than paper-based homework.	56.4	115	27.9	57	7.4	15	2	4	5.4	11	1	2	1.75
E12	Online maths homework helps me evaluate my own understanding and performance.	61.8	126	28.4	58	7.8	16	0.5	1	1.5	3			1.52
E13	I like online maths homework more than paper-based maths homework.	64.2	131	30.4	62	2.9	6			1.5	3	1	2	1.47
E14	I feel I can be better at maths as a result of online maths homework.	61.8	126	28.9	59	4.9	1			1.5	3	2.9	6	1.6
E15	I am more motivated to do my maths homework on the computer than on paper.	63.7	130	25.5	52	7.4	15			2.5	5	0.5	1	1.53
E16	I am easily distracted when doing online maths homework.	26	53	13.7	28	10.8	22	7.4	15	30.9	63	11.3	23	3.38
E17	I discuss my online maths homework with my classmates and others.	60.8	124	20.6	42	6.4	13	8.8	18	2.5	5	1	2	1.75
E18	My parents are more keen to monitor my progress in maths because of online homework.	59.8	122	28.4	58	3.4	7	0.5	1	5.4	11	2.5	5	1.69
E19	I get help from my family, friends and others in completing my online maths homework.	58.3	119	27	55	8.8	18	1	2	4.9	1			1.67
E20	Paper based homework is just as effective as online maths homework.	62.3	127	17.6	36	7.8	16	8.3	17	2.5	5	1.5	3	1.76
E21	Online maths homework is better than Paper based maths homework.	61.8	126	23	47	8.8	18	1	2	3.9	8	1.5	3	1.67
E22	The use of English language for my online maths homework is not a problem.	56.4	115	28.4	58	2	4	1.5	3	10.8	22	1	2	1.83
E23	My teacher encourages the use of online maths homework.	69.6	142	21.1	43	4.4	9	2.5	5	1.5	3	1	2	1.56
E24	My maths has improved as a result of online homework.	64.7	132	27.5	56	6.4	13			1	2	0.5	1	1.47
E25	I spend more time on my maths homework because I can interact with the maths.	61.8	126	25	51	8.8	18	1	2	2.5	5	1	2	1.61

Appendix 33 – Survey Item Correlations for Constructs 1, 2 and 3

Item Correlations for Construct 1

Spearman's rho		E1	E2	E3	E4	E5	E9	E17	E25
E1	Correlation Coefficient	1.000	.872**	.693**	.408**	.639**	.341**	.583**	.476**
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000	.000
E2	Correlation Coefficient		1.000	.644**	.508**	.574**	.379**	.547**	.570**
	Sig. (2-tailed)		.	.000	.000	.000	.000	.000	.000
E3	Correlation Coefficient			1.000	.443**	.560**	.335**	.544**	.484**
	Sig. (2-tailed)			.	.000	.000	.000	.000	.000
E4	Correlation Coefficient				1.000	.410**	.269**	.527**	.471**
	Sig. (2-tailed)				.	.000	.000	.000	.000
E5	Correlation Coefficient					1.000	.361**	.439**	.416**
	Sig. (2-tailed)					.	.000	.000	.000
E9	Correlation Coefficient						1.000	.347**	.570**
	Sig. (2-tailed)						.	.000	.000
E17	Correlation Coefficient							1.000	.507**
	Sig. (2-tailed)							.	.000
E25	Correlation Coefficient								1.000
	Sig. (2-tailed)								.

**. Correlation is significant at the 0.01 level (2-tailed).

Item Correlations for Construct 2

Spearman's rho		E6	E7	E8	E10	E11	E18	E19
E6	Correlation Coefficient	1.000	.361**	.577**	.545**	.416**	.433**	.520**
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000
E7	Correlation Coefficient		1.000	.484**	.508**	.492**	.452**	.452**
	Sig. (2-tailed)		.	.000	.000	.000	.000	.000
E8	Correlation Coefficient			1.000	.700**	.523**	.492**	.482**
	Sig. (2-tailed)			.	.000	.000	.000	.000
E10	Correlation Coefficient				1.000	.389**	.476**	.574**
	Sig. (2-tailed)				.	.000	.000	.000
E11	Correlation Coefficient					1.000	.448**	.489**
	Sig. (2-tailed)					.	.000	.000
E18	Correlation Coefficient						1.000	.666**
	Sig. (2-tailed)						.	.000

E19	Correlation Coefficient	1.000
	Sig. (2-tailed)	.

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

Spearman's rho		E9	E12	E13	E14	E15	E21	E24
E9	Correlation Coefficient	1.000	.267**	.446**	.433**	.352**	.489**	.371**
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000
E12	Correlation Coefficient		1.000	.692**	.578**	.483**	.350**	.436**
	Sig. (2-tailed)		.	.000	.000	.000	.000	.000
E13	Correlation Coefficient			1.000	.717**	.507**	.388**	.541**
	Sig. (2-tailed)			.	.000	.000	.000	.000
E14	Correlation Coefficient				1.000	.455**	.402**	.464**
	Sig. (2-tailed)				.	.000	.000	.000
E15	Correlation Coefficient					1.000	.495**	.580**
	Sig. (2-tailed)					.	.000	.000
E21	Correlation Coefficient						1.000	.425**
	Sig. (2-tailed)						.	.000
E24	Correlation Coefficient							1.000
	Sig. (2-tailed)							.

**. Correlation is significant at the 0.01 level (2-tailed).

Table 26 shows the item correlations for Construct 3 and this table also indicate that there is statistically significant correlation between the items with $p < .01$. This analysis also indicate that Construct 3 also shows high construct validity.

References

Abdeljaouad, M. (2006) ‘Issues in the history of mathematics teaching in Arab countries’, *Paedagogica Historica*, 42(4–5), pp. 629–664. doi: 10.1080/00309230600806930.

Abida, K. and Muhammad, A. (2012) ‘Constructivist Vs Traditional : Effective instructional approach in teacher education’, *International Journal of Humanities and Social Science*, 2(5), pp. 170–177. Available at: http://www.ijhssnet.com/journals/Vol_2_No_5_March_2012/21.pdf (Accessed: 10 July 2013).

ADEC (2012) ‘Abu Dhabi Education Reform : The Road to 2030’. Available at: http://www.insead.edu/facultyresearch/centres/innovation_policy_initiative/breakfasts/past/documents/ad_edu_ref_pres.pdf.

ADEC (2014) ‘Mathematics Curriculum Guide for Grades 8-11 2014-2015’. Available at: ADEC online http://www.insead.edu/facultyresearch/centres/innovation_policy_initiative/breakfasts/past/documents/ad_edu_ref_pres.pdf.

Afari, E., Ward, G. and Khine, M. S. (2012) ‘Global Self-Esteem and Self-Efficacy Correlates: Relation of Academic Achievement and Self-Esteem among Emirati Students’, *International Education Studies*, 5(2), pp. 49–57. doi: 10.5539/ies.v5n2p49.

Affouf, B. M. and Walsh, T. P. (2006) ‘An Assessment of Web-Based Homework in the Teaching of College Algebra’, 14(4).

Al-Awidi, H. M. and Alghazo, I. M. (2012) ‘The effect of student teaching experience on preservice elementary teachers’ self-efficacy beliefs for technology integration in the UAE’, *Educational Technology Research and Development*, 60(5), pp. 923–941. doi: 10.1007/s11423-012-9239-4.

Albright, D., Bass, C. and Johnson, M. (2007) ‘Do Students Feel that Homework is a Necessary and Meaningful Part of Their Education?’, *Emurillo.Org*. Available at: http://emurillo.org/Classes/Class2/documents/HomeworkMeaningful.doc (Accessed: 2 July 2013).

Alexander, M. W. *et al.* (2001) ‘Testing in a Computer Technology Course: An Investigation of Equivalency in Performance Between Online and Paper and Pencil Methods’, *Journal of Career and Technical Education*, 18(1), pp. 69–80. doi: 10.21061/jcte.v18i1.600.

Alexander, N. (2013) ‘Exploring attitudes and achievement of web-based homework’, *The Turkish Online Journal of Educational Technology*, 12(4), pp. 75–80.

Allen, G. D. (2007) *Islamic Mathematics and Mathematicians, The History of Mathematics*. Available at: http://www.math.tamu.edu/~dallen/masters/islamic/arab.pdf.

Almekhlafi, A. G. and Almeqdadi, F. A. (2010) 'Teachers' perceptions of technology integration in the United Arab Emirates school classrooms', *Educational Technology and Society*, 13(1), pp. 165–175. doi: 10.2307/jeductechsoci.13.1.165.

Amuthabala, P. (2014) 'M-Learning in Education', *International Journal of Research in Engineering and Technology*. New York: Nature Publishing Group, 2003. doi: 10.15623/ijret.2014.0305017.

Anderson-Cook, C. M. (2005) 'Experimental and Quasi-Experimental Designs for Generalized Causal Inference', *Journal of the American Statistical Association*, 100(470), pp. 708–708. doi: 10.1198/jasa.2005.s22.

Anderson-Pence, K. L. (2015) 'Teachers' perceptions of examining students' thinking: Changing mathematics instructional practice', *Cogent Education*. Cogent, 2(1), p. 1075329. doi: 10.1080/2331186X.2015.1075329.

Aqsha, M. *et al.* (2011) 'The Perception and Method in Teaching and Learning Islamic Education', *International Journal of Education and Information Technologies*, 5(1), pp. 69–78. Available at: http://www.naun.org/multimedia/NAUN/educationinformation/19-561.pdf (Accessed: 13 July 2013).

Arbain, N. and Shukor, N. A. (2015) 'The Effects of GeoGebra on Students Achievement', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 172(February), pp. 208–214. doi: 10.1016/j.sbspro.2015.01.356.

Ashcraft, M. H. (2002) 'Math Anxiety: Personal, Educational, and Cognitive Consequences', *Current Directions in Psychological Science*, 11(5), pp. 181–185. doi: 10.1111/1467-8721.00196.

Ashcraft, M. H. and Kirk, E. P. (2001) 'The relationships among working memory, math anxiety, and performance', *Journal of Experimental Psychology: General*, 130(2), pp. 224–237. doi: 10.1037/0096-3445.130.2.224.

Auld, R. G., Belfiore, P. J. and Scheeler, M. C. (2010) 'Increasing pre-service teachers' use of differential reinforcement: Effects of performance feedback on consequences for student behavior', *Journal of Behavioral Education*, 19(2), pp. 169–183. doi: 10.1007/s10864-010-9107-4.

Bahgat, G. (1999) 'Education in the Gulf monarchies: Retrospect and prospect', *International Review of Education*, 45(2), pp. 127–136. doi: 10.1023/A:1003610723356.

Bandura, A. (1978) 'Self-efficacy: Toward a unifying theory of behavioral change', *Advances in Behaviour Research and Therapy*, 1(4), pp. 139–161. doi: 10.1016/0146-6402(78)90002-4.

Barbour, R. (2011) ‘Doing Focus Groups’, *Doing Focus Groups*, pp. 203–223. doi: 10.4135/9781849208956.

Bembenutty, H. (2011) ‘Meaningful and Maladaptive Homework Practices: The Role of Self-Efficacy and Self-Regulation’, *Journal of Advanced Academics*, 22(3), pp. 448–473. doi: 10.1177/1932202X1102200304.

Bennett, S. and Kalish, N. (2006) ‘The case against homework’, *New York: Crown*. Available at: http://thecaseagainsthomework.com/Press-Release.pdf (Accessed: 23 December 2013).

Bessière, K. *et al.* (2006) ‘A model for computer frustration: the role of instrumental and dispositional factors on incident, session, and post-session frustration and mood’, *Computers in Human Behavior*, 22(6), pp. 941–961. doi: 10.1016/j.chb.2004.03.015.

Van Beuningen, C. G., De Jong, N. H. and Kuiken, F. (2012) ‘Evidence on the Effectiveness of Comprehensive Error Correction in Second Language Writing’, *Language Learning*, 62(1), pp. 1–41. doi: 10.1111/j.1467-9922.2011.00674.x.

Bicanich, E. *et al.* (1997) ‘Internet-Based Testing: A Vision or Reality?.’, *T.H.E. Journal*, 25(2), pp. 61–64.

Black, P. *et al.* (2003) ‘Assessment for learning: putting it into practice (Buckingham, Open University Press)’, *General Teaching Council for England AfL*, (September), pp. 1–28. Available at: http://oro.open.ac.uk/24157/ (Accessed: 27 November 2013).

Black, P. and Wiliam, D. (1998) ‘Assessment and classroom learning’, *International Journal of Phytoremediation*, 21(1), pp. 7–74. doi: 10.1080/0969595980050102.

Bliwise, N. G. (2005) ‘Web-based tutorials for teaching introductory statistics’, *Journal of Educational Computing Research*, 33(3), pp. 309–325. doi: 10.2190/0D1J-1CE1-5UXY-3V34.

Boli, J. (2006) ‘National Differences, Global Similarities: World Culture and the Future of Schooling’, *Contemporary Sociology: A Journal of Reviews*, pp. 313–315. doi: 10.1177/009430610603500361.

Bonham, S. W., Deardorff, D. L. and Beichner, R. J. (2003) ‘Comparison of student performance using web and paper-based homework in college-level physics’, *Journal of Research in Science Teaching*, 40(10), pp. 1050–1071. doi: 10.1002/tea.10120.

Bower, G. H. and Hilgard, E. R. (1981) *Theories of Learning*, *October*. Available at: http://www.brookes.ac.uk/services/ocsd/2_learntch/theories.html#sensory.

Braun, V. and Clarke, V. (2006) ‘Using thematic analysis in psychology’, *Qualitative Research in Psychology*, 3(2), pp. 77–101. doi: 10.1191/1478088706qp063oa.

Brewer, D. S. (2009) *The Effects of Online Homework on Achievement and Self-Efficacy of College Algebra Students, ProQuest LLC*. ProQuest LLC. 789 East Eisenhower Parkway, P.O. Box 1346, Ann Arbor, MI 48106. Tel: 800-521-0600; Web site: http://www.proquest.com/en-US/products/dissertations/individuals.shtml. Available at: http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED513252.

Briggs, S. R. and Cheek, J. M. (1986) 'The role of factor analysis in the development and evaluation of personality scales', *Journal of Personality*, 54(1), pp. 106–148. doi: 10.1111/j.1467-6494.1986.tb00391.x.

Briscoe, W. (2012) *The use of GeoGebra in teaching A-Level Mathematics*. Available at: http://actionresearch.farnborough.ac.uk/files/arp/file/wesley briscoe arp.pdf.

Brooks, J. and Psychologist, T. (2015) 'Learning from the " lifeworld " Final author version', *The Psychologist*, 28(August), pp. 645–646. Available at: https://thepsychologist.bps.org.uk/volume-28/august-2015/learning-lifeworld.

Brown, S. A. *et al.* (2002) 'Do I really have to? User acceptance of mandated technology', *European Journal of Information Systems*, 11(4), pp. 283–295. doi: 10.1057/palgrave.ejis.3000438.

Bruner, J. (1985) 'Models of the Learner', *Educational Researcher*, 14(6), pp. 5–8. doi: 10.3102/0013189X014006005.

Buell, E. K. and J. (2000) '___Article_End_Homework_Now__Kralovec___Buell_.Pdf'. EBSCO. Available at: http://home.roadrunner.com/~misswong/journal.pdf.

Bull, H. (2009) 'Identifying maths anxiety in student nurses and focusing remedial work', *Journal of Further and Higher Education*, 33(1), pp. 71–81. doi: 10.1080/03098770802638689.

Bunz, U. H. F. (2010) *α-Oligofurans: Molecules without a twist*. 5th ed. /, *Angewandte Chemie - International Edition*. 5th ed. /. Boston, Mass. ; London : Pearson/Allyn & Bacon. doi: 10.1002/anie.201002458.

Carter, C. B. and Norton, M. G. (2013) 'Ceramic materials: Science and engineering', *Ceramic Materials: Science and Engineering*, 6(4), pp. 1–766. doi: 10.1007/978-1-4614-3523-5.

Cattell, R. B. (1966) 'The scree test for the number of factors', *Multivariate Behavioral Research*, 1(2), pp. 245–276. doi: 10.1207/s15327906mbr0102_10.

Ceaparu, I. *et al.* (2004) 'Determining causes and severity of end-user frustration', *International Journal of Human-Computer Interaction*, 17(3), pp. 333–356. doi: 10.1207/s15327590ijhc1703_3.

ChallengeSuccess (2012) ‘Changing the Conversation About Homework from Quantity and Achievement To Quality and Engagement’, pp. 1–9. Available at: http://www.challengesuccess.org/portals/0/docs/ChallengeSuccess-Homework-WhitePaper.pdf.

Charmaz, K. (2006) *Constructing Grounded Theory : A Practical Guide through Qualitative Analysis*. London: Sage.

Ciaran Browne, B. (2013) ‘Recording the Personal: The Benefits in Maintaining Research Diaries for Documenting the Emotional and Practical Challenges of Fieldwork in Unfamiliar Settings.’, *International Journal of Qualitative Methods*, 12(1), pp. 420–435. Available at: http://pirate.24nieuwe.nl/http://ejournals.library.ualberta.ca/index.php/IJQM/article/view/16386 (Accessed: 12 December 2013).

Clark, L. A. and Watson, D. (1995) ‘Constructing Validity: Basic Issues in Objective Scale Development’, *Psychological Assessment*, 7(3), pp. 309–319. doi: 10.1037/1040-3590.7.3.309.

Clarke, K. (2016) ‘Homework in UAE schools: To ban or not to ban?’, *Khaleej Times*. Available at: https://www.khaleejtimes.com/nation/education/homework-in-uae-schools-to-ban-or-not-to-ban%0Awww.khaleejtimes.com/nation/education/homework-in-uae-schools-to-ban-or-not-to-ban (Accessed: 25 September 2019).

Cofer, C. N. and Skinner, B. F. (1969) *The Technology of Teaching*, *The American Journal of Psychology*. Meredith Corporation. doi: 10.2307/1420451.

Cohen, D. and Crabtree, B. (2006) ‘Semi-structured Interviews Recording Semi-Structured interviews’, *Qualitative Research Guidelines Project*, p. 2. Available at: http://www.qualres.org/HomeSemi-3629.html.

Cohen, J. (2013) *Statistical Power Analysis for the Behavioral Sciences*. second, *Statistical Power Analysis for the Behavioral Sciences*. second. Edited by LAWRENCE ERLBAUM ASSOCIATES. LAWRENCE ERLBAUM ASSOCIATES. doi: 10.4324/9780203771587.

Cohen, L., Manion, L. and Morrison, K. (2007) *Research Methods in Education*, *Education*. Edited by 6th. Routledge. doi: 10.1111/j.1467-8527.2007.00388_4.x.

Cooper, H. (1989) ‘Synthesis of Research on Homework.pdf’, *Educational leadership*. Available at: http://www.addison.pausd.org/files/addison/homework/Synthesis of Research on Homework.pdf (Accessed: 25 June 2013).

Cooper, H. (2008) ‘Homework: What the Research Says’, *Nctm*, (703), pp. 1–3. Available at: http://www.allspammedup.com/2013/02/a-brief-history-of-spam-in-the-beginning/.

Cooper, H., Robinson, J. C. and Patall, E. A. (2006) 'Does homework improve academic achievement? A synthesis of research, 1987-2003', *Review of Educational Research*, 76(1), pp. 1–62. doi: 10.3102/00346543076001001.

Cooper, H. and Valentine, J. C. (2001) 'Using Research to Answer Practical Questions About Homework', *Educational Psychologist*. Routledge, 36(3), pp. 143–153. doi: 10.1207/S15326985EP3603_1.

Cooper, P. a. (1993) 'Paradigm Shifts in Designed Instruction- From Behaviorism to Cognitivism to Constructivism', *Educational technology*, 35(3), pp. 12–19.

Corbin, J. M. and Strauss, A. L. (1998) *Basics of Qualitative Research*. Available at: http://www.google.com/books?id=wTwYUnHYsmMC%5Cnhttp://en.wikipedia.org/wiki/Grounded_theory.

Coutts, P. M. (2004) 'Meanings of homework and implications for practice', *Theory into Practice*, 43(3), pp. 182–188. doi: 10.1353/tip.2004.0034.

Crain, W. (2005) 'An Interview With Alfie Kohn'. Available at: http://www.nipissingu.ca/EDUCATION/carlor/publishedpapers/ExamsAndTheLearningEnvironment.pdf (Accessed: 22 December 2013).

Cresswell, J. W., Ivankova, N. V and Stick, S. . (2006) 'Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice', *Field Methods*, 18(1), pp. 3–20. doi: 10.1177/1525822X05282260.

DCSF Department for Children Schools and Families (2009) *Involving parents in secondary mathematics: case studies A-E*.

Demirci, N. (2007) 'of Web-based vs . Paper-based Homework in a General Physics', *Eurasia Journal of Mathematics, Science & Technology Education*, 3(1), pp. 29–34.

Demirci, N. (2010) 'Web-Based vs. Paper-Based Homework to Evaluate Students' Performance in Introductory Physics Courses and Students' Perceptions: Two Years Experience', *International Journal on E-learning*, 9(October), pp. 27–49. Available at: http://www.editlib.org/p/28175?nl.

Dettmers (2010) 'Effektive Hausaufgaben : Untersuchungen zu einem psychologischen Rahmenmodell', (April). Available at: http://d-nb.info/1024866351/ (Accessed: 28 June 2013).

Dillard-Eggers, J. *et al.* (2008) 'Evidence On The Effectiveness Of On-Line Homework', *College Teaching Methods & Styles Journal (CTMS)*, 4(5), pp. 9–16. doi: 10.19030/ctms.v4i5.5548.

Dimitrov, D. M. and Rumrill, P. D. (2003) ‘Pretest-posttest designs and measurement of change.’, *Work (Reading, Mass.)*, 20(2), pp. 159–65. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12671209.

Donovan, M. S. *et al.* (1999) ‘How People Learn: Bridging Research and Practice’, *National Academy of Sciences*, p. 88. Available at: http://www.nap.edu/catalog/9457.html.

Doorn, D. J., Janssen, S. and O’Brien, M. (2010) ‘Student Attitudes and Approaches to Online Homework’, *International Journal for the Scholarship of Teaching and Learning*, 4(1), pp. 1–21. doi: 10.20429/ijsotl.2010.040105.

Dowson, M. and Mcinerney, D. M. (2004) ‘The development and validation of the Goal Orientation and Learning Strategies Survey (GOALS-S)’, *Educational and Psychological Measurement*, 64(2), pp. 290–310. doi: 10.1177/0013164403251335.

Dufresne, R. *et al.* (2002) ‘The Effect of Web-Based Homework on Test Performance in Large Enrollment Introductory Physics Courses’, *Jl. of Computers in Mathematics and Science Teaching*, 21(21(3)), pp. 229–251.

Espasa, A. and Meneses, J. (2010) ‘Analysing feedback processes in an online teaching and learning environment: An exploratory study’, *Higher Education*, 59(3), pp. 277–292. doi: 10.1007/s10734-009-9247-4.

Falagas, M. E., Zarkadoulia, E. A. and Samonis, G. (2006) ‘Arab science in the golden age (750-1258 C.E.) and today.’, *FASEB journal : official publication of the Federation of American Societies for Experimental Biology*, 20(10), pp. 1581–6. doi: 10.1096/fj.06-0803ufm.

Falch, T. (2011) ‘Homework assignment and student achievement in OECD countries _ Department of Economics Homework assignment and student achievement in OECD countries ∗’, (5).

Farah, S. and Ridge, N. (2015) ‘Challenges to Curriculum Development in the UAE’, *Dubai School of Government, Dubai*, pp. 1–7. Available at: http://www.dsg.ae/En/Publication/Pdf_En/DSG Policy Brief 16 English.pdf (Accessed: 8 July 2013).

Farrell, E. F. (2006) ‘Taking Anxiety Out of the Equation Some professors say colleges should make mathematics more student-friendly’, *The Chronicle of Higher Education*, January 13. Available at: http://inthenews.unt.edu/sites/default/files/PDF/2006/1/13/01_13_2006_che_takingan.pdf (Accessed: 21 December 2013).

Felix, N., Dornbrack, J. and Scheckle, E. (2008) ‘Parents, homework and socio-economic class: Discourses of deficit and disadvantage in the “new” South Africa’, *English Teaching*, 7(2), pp. 99–112. Available at: https://education.waikato.ac.nz/research/files/etpc/2008v7n2art6.pdf (Accessed: 2 July 2013).

Feng, M., Heffernan, N. T. and Koedinger, K. R. (2006) ‘Addressing the testing challenge with a web-based e-assessment system that tutors as it assesses’, *Proceedings of the 15th International Conference on World Wide Web*, pp. 307–316. doi: 10.1145/1135777.1135825.

Ferketich, S. (1991) ‘Focus on psychometrics. Aspects of item analysis’, *Research in Nursing & Health*, 14(2), pp. 165–168. doi: 10.1002/nur.4770140211.

Ferreira, A., Moore, J. D. and Mellish, C. (2007) ‘A study of feedback strategies in foreign language classrooms and tutorials with implications for intelligent computer-assisted language learning systems’, *International Journal of Artificial Intelligence in Education*, 17(4), pp. 389–422.

Fund, Z. (2010) ‘Effects of communities of reflecting peers on student-teacher development - Including in-depth case studies’, *Teachers and Teaching: Theory and Practice*, 16(6), pp. 679–701. doi: 10.1080/13540602.2010.517686.

Gardner, D. P. (1983) *A Nation at Risk: The Imperative for Educational Reform, Journal of Policy Analysis and Management*. doi: 10.2307/3323945.

Garelick, B. (2005) ‘The new, a-maze-ing approach to math’, *Education Next*, 5(2), pp. 28–36. Available at: file:///C:/Users/sean/Desktop/PhD/An-A-Maze-ing-Approach-To-Math-_-Education-Next.pdf.

Garii, B. and Rule, A. C. (2009) ‘Integrating social justice with mathematics and science: An analysis of student teacher lessons’, *Teaching and Teacher Education*. Elsevier Ltd, 25(3), pp. 490–499. doi: 10.1016/j.tate.2008.11.003.
Gergelitsov´a, S. (2014) *Using geogebra applets for homework assignments*. Computer Science Journal Biuletyn of Polish Society for Geometry and Engineering Graphics.

Gergelitsová, Š. and Holan, T. (2016) ‘GeoTest - A system for the automatic evaluation of geometry-based problems’, *Computer Applications in Engineering Education*, 24(2), pp. 297–304. doi: 10.1002/cae.21712.

Gill, B. P. & S. L. S. (1996) ‘Sin-Against-Childhood.Pdf’. American Journal of Education, pp. 1–126. doi: Volume 105, No. 1.

Gill, B. P. & S. L. S. (2004) ‘villiain-or-savior.pdf’. The Ohio State University, pp. 174–181. Available at: http://www.history.cmu.edu/docs/schlossman/villiain-or-savior.pdf.

Gill, B. and Schlossman, S. (2000) ‘The lost cause of homework reform’, *American Journal of Education*, 109(1), pp. 27–62. doi: 10.1086/444258.

Goodman, J. I. *et al.* (2008) ‘The Effects of “Bug-in-Ear” Supervision on Special Education Teachers’ Delivery of Learn Units’, *Focus on Autism and Other Developmental Disabilities*, 23(4), pp. 207–216. doi: 10.1177/1088357608324713.

Goulding, M. (2003) ‘An Investigation into the Mathematical Knowledge of Primary Teacher Trainees’, in *Proceedings of the British Society for Research into Learning Mathematics*, pp. 73–78. Available at: http://bsrlm.org.uk/IPs/ip23-3/BSRLM-IP-23-3-13.pdf%0Ahttp://www.bsrlm.org.uk/wp-content/uploads/2016/02/BSRLM-IP-23-3-13.pdf (Accessed: 19 December 2013).

Graff, M., Mayer, P. and Lebens, M. (2008) ‘Evaluating a web based intelligent tutoring system for mathematics at German lower secondary schools’, *Education and Information Technologies*, 13(3), pp. 221–230. doi: 10.1007/s10639-008-9062-z.

Greene, B. A. and Miller, R. B. (1996) ‘Influences on achievement: Goals, perceived ability, and cognitive engagement’, *Contemporary Educational Psychology*, 21(2), pp. 181–192. doi: 10.1006/ceps.1996.0015.

Greenhalgh, S. (2016a) ‘MAKING THE GRADE ? Critical Thinking ...Analyzing the state of education across Asia, from grade school to trade school’, *The Asian Development Bank*. Available at: https://thediplomat.com/2016/12/the-hidden-costs-of-asias-high-test-scores/.

Greenhalgh, S. (2016b) *The Hidden Costs of Asia’s High Test Scores | The Diplomat*, *The Diplomat*. Available at: https://thediplomat.com/2016/12/the-hidden-costs-of-asias-high-test-scores/.

Guthrie, L. C. *et al.* (2014) ‘Time perspective and exercise, obesity, and smoking: Moderation of associations by age’, *American Journal of Health Promotion*, 29(1), pp. 9–16. doi: 10.4278/ajhp.130122-QUAN-39.

Güven, B. and Kosa, T. (2008) ‘The effect of dynamic geometry software on student mathematics teachers’ spatial visualization skills’, *Turkish Online Journal of Educational Technology*, 7(4), pp. 100–107.

Hartas, D. (2010) *Educational Research and Inquiry: qualitative and quantitative approaches*. Edited by D. Hartas. London: Continuum International Publishing Group.

Hattie, J. (1999) ‘Influences on student learning’, pp. 1–25. Available at: http://growthmindseteaz.org/johnhattie.html (Accessed: 1 October 2019).

Hattie, J. and Timperley, H. (2007) ‘The Power of Feedback’, *Review of Educational Research*, 77(1), pp. 81–112. doi: 10.3102/003465430298487.

Hauk, S., Powers, R. A. and Segalla, A. (2015) ‘A Comparison of Web-based and Paper-and-Pencil Homework on Student Performance in College Algebra’, *Primus*, 25(1), pp. 61–79. doi: 10.1080/10511970.2014.906006.

Hauk, S. and Segalla, A. (2005) ‘Student perceptions of the web-based homework program WeBWork in moderate enrollment college algebra classes’, *Journal of Computers in Mathematics and Science Teaching*, 24(3), pp. 229–253.

Hembree, R. (1990) ‘The Nature, Effects, and Relief of Mathematics Anxiety’, *Journal for Research in Mathematics Education,* Vol. 21, N(No. 1 Jan., 1990), pp. 33–46. Available at: http://www.jstor.org/stable/749455 (Accessed: 30 June 2013).

Hembree, R. (2006) ‘The Nature, Effects, and Relief of Mathematics Anxiety’, *Journal for Research in Mathematics Education*, 21(1), p. 33. doi: 10.2307/749455.

Hirsch, L. and Weibel, C. (2003) ‘Statistical Based Evidence that Web-Based Homework Helps’, *MAA Focus*, 23(2), p. 14.

Hodge, J. E. (2002) *The effect of math anxiety, math self -efficacy, and computer -assisted instruction on the ability of undergraduate nursing students to calculate drug dosages, ProQuest Dissertations and Theses*. Available at: https://search.proquest.com/docview/305500978

Holan, T. (2014) ‘Proceedings of 21st conference on Domain Decompostion methods’, in *USING GEOGEBRA APPLETS FOR HOMEWORK ASSIGNMENTS*, pp. 22–23.

Horn, R. (2012) *Researching and Writing Dissertations: A Complete Guide for Business and Management Students*. Thomson Learning. Available at: https://books.google.ae/books? (Accessed: 7 May 2017).

Hsieh, H. F. and Shannon, S. E. (2005) ‘Three approaches to qualitative content analysis’, *Qualitative Health Research*, 15(9), pp. 1277–1288. doi: 10.1177/1049732305276687.

Ifeanyi, I. P. and Chukwuere, J. E. (2018) ‘The impact of using smartphones on the academic performance of undergraduate students’, *Knowledge Management and E-Learning*, 10(3), pp. 290–308. doi: 10.34105/j.kmel.2018.10.017.

Innabi, H. (2009) *A Model to Develop Mathematics Education: Modify the Public Traditional Perceptions of Mathematics-Case of UAE Schools’ Principals*. Available at: http://www.qucosa.de/recherche/frontdoor/cache.off (Accessed: 25 July 2013).

Jehn, K. A. and Doucet, L. (1997) ‘Developing categories for interview data: Consequences of different coding and analysis strategies in understanding text: Part 2’, *Field Methods*, 9(1), pp. 1–7. doi: 10.1177/1525822X970090010101.

Johnston-Wilder, S. and Lee, C. (2008) ‘Mathematical Resilience University of Warwick , Coventry , United Kingdom , 2 Open University , Milton Keynes , United Kingdom Background Research Questions Research findings’, (Newman 2004), pp. 2–4.

Jones, C. (2008) ‘Student perceptions of the impact of web-based homework on course interaction and learning in introductory accounting’, *Issues in Information Systems*, IX(1). Available at: http://iacis.org/iis/2008/S2008_1116.pdf (Accessed: 2 September 2013).

Kaiser, H. F. (1974) ‘An index of factorial simplicity’, *Psychometrika*, 39(1), pp. 31–36. doi: 10.1007/BF02291575.

Kargwell, S. A. (2012) ‘A comparative study on gender and entrepreneurship development : Still a male ’ s world within UAE cultural context’, *International Journal of Business and Social Science*, 3(6), pp. 44–56.

Katmada, A., Satsiou, A. and Kompatsiaris, I. (2016) ‘A reputation-based incentive mechanism for a crowdsourcing platform for financial awareness’, *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 10078 LNCS(4), pp. 57–80. doi: 10.1007/978-3-319-50237-3_2.

Kats-Gold and Priel (2009) ‘Emotion, understanding, and socil skills among boys at risk of ADHD’, *Psychology in the schools*, 46(7), pp. 2004–2007. doi: 10.1002/pits.

Kaune, C. (2006) ‘Reflection and metacognition in mathematics education - tools for the improvement of teaching quality’, *ZDM - International Journal on Mathematics Education*, 38(4), pp. 350–360. doi: 10.1007/BF02652795.

Khanlarian, C. J. (2011) *A longitudinal study of web-based homework.*, *Dissertation Abstracts International: Section B: The Sciences and Engineering*. Available at: http://gateway.proquest.com/openurl.

Al Khatib, S. a. (2012) ‘Exploring the Relationship among Loneliness, Self-esteem, Self-efficacy and Gender in United Arab Emirates College Students’, *Europe’s Journal of Psychology*, 8(1), pp. 159–181. doi: 10.5964/ejop.v8i1.301.

Van Der Kleij, F. M. *et al.* (2012) ‘Effects of feedback in a computer-based assessment for learning’, *Computers and Education*. Elsevier Ltd, 58(1), pp. 263–272. doi: 10.1016/j.compedu.2011.07.020.

Van der Kleij, F. M., Feskens, R. C. W. and Eggen, T. J. H. M. (2015) ‘Effects of Feedback in a Computer-Based Learning Environment on Students’ Learning Outcomes: A Meta-Analysis’, *Review of Educational Research*, 85(4), pp. 475–511. doi: 10.3102/0034654314564881.

Kodippili, A. and Senaratne, D. (2008) ‘Is computer-generated interactive mathematics homework more effective than traditional instructor-graded homework?’, *British Journal of Educational Technology*, 39(5), pp. 928–932. doi: 10.1111/j.1467-8535.2007.00794.x.

Kohn, A. (2006) ‘Down with Homework.’, *Instructor*. Available at: http://www.alfiekohn.org/teaching/dwh.htm (Accessed: 24 December 2013).

Kondracki, N. and Wellman, D. (2012) *Content analysis: Introduction, How to design and evaluate research in education*. Available at: http://www.audiencedialogue.net/kya16a.html.

Kul, U. (2012) ‘Turkish mathematics teachers’ experiences with Geogebra activities: changes in beliefs’, *Research in Mathematics Education*, 14(3), pp. 293–294. doi: 10.1080/14794802.2012.734984.

Kulhavy, R. W. (1977) ‘Feedback in Written Instruction’, *Review of Educational Research*, 47(2), pp. 211–232. doi: 10.3102/00346543047002211.

Laerd Statistics (2015) *INDEPENDENT-SAMPLES T-TEST, Laerd Statistics*. Available at: https://statistics.laerd.com/premium/spss/istt/independent-t-test-in-spss-24.php (Accessed: 10 June 2016).

Laistner, N. (2016) *Metacognition and Student Achievement in Mathematics*. State University of New York. Available at: http://www.brockport.edu/ehd/ Recommended.

Lance, C. E., Butts, M. M. and Michels, L. C. (2006) ‘What Did They Really Say ?’, *Organizational Research Methods*, 9(2), pp. 202–220. doi: 10.1177/1094428105284919.

Larose, P. G. (2010) ‘The impact of implementing web homework in second-semester calculus’, *Primus*, 20(8), pp. 664–683. doi: 10.1080/10511970902839039.

Lenth, R. V (2007) ‘Some Practical Guidelines for Effective Sample Size Determination’, 55(3), pp. 187–193.

Li, L., Liu, X. and Steckelberg, A. L. (2010) ‘Assessor or assessee: How student learning improves by giving and receiving peer feedback’, *British Journal of Educational Technology*, 41(3), pp. 525–536. doi: 10.1111/j.1467-8535.2009.00968.x.

Libbey, H. P. (2004) ‘Measuring student relationships to school: Attachment, bonding, connectedness, and engagement’, *Journal of School Health*, 74(7), pp. 274–283. doi: 10.1111/j.1746-1561.2004.tb08284.x.

Locklear, Dawn, Walden U., U. (2013) *Using online homework in a liberal arts math course to increase student participation and performance., Dissertation Abstracts International Section A: Humanities and Social Sciences*. Available at: http://scholar.google.com/scholar (Accessed: 2 July 2013).

Mackenzie, S. (2002) ‘Can we make maths count at he?’, *Journal of Further and Higher Education*, 26(2), pp. 159–171. doi: 10.1080/03098770220129433.

Mahendra, Nidhi; Bayles, Kathryn; Tomoeda, Cheryl & Kim, E. (2005) ‘Diversity and Learner-Centered Education’. ASHA. Available at: http://www.asha.org/Publications/leader/2005/051129/f051129c.htm (Accessed: 29 October 2013).

Mallick, S. *et al.* (2011) ‘Simplifying Web service discovery & validating service composition’, *Proceedings - 2011 IEEE World Congress on Services, SERVICES 2011*, (2005), pp. 288–294. doi: 10.1109/SERVICES.2011.60.

Mangione, L. (2008) ‘Is homework working?’, *Phi Delta Kappan*, 89(8), pp. 614–615. doi: 10.1177/003172170808900820.

Mangione, L. (2012) ‘Homework Has Value When It Reinforces Learning’, *Phi Delta Kappan*, 89(8), pp. 614–615. Available at: http://ic.galegroup.com/ic/ovic/ViewpointsDetailsPage/ViewpointsDetailsWindow.

Martens, R. *et al.* (2010) ‘Inducing mind sets in self-regulated learning with motivational information’, *Educational Studies*, 36(3), pp. 311–327. doi: 10.1080/03055690903424915.

Marzano, R. J. and Pickering, D. J. (2007) ‘Special topic/The case for and against homework’, *Educational Leadership*, 64(6), pp. 74–79.

Mastin, L. (2010) *Islamic Mathematics - The Story of Mathematics*. Available at: http://www.storyofmathematics.com/islamic.html (Accessed: 27 July 2013).

Mavrikis & Maciocia (2003) *Incorporating assessment into an Interactive Learning Environment for mathematics*, *Maths CAA Series: June 2003*. Available at: http://www.mathstore.ac.uk/articles/maths-caa-series/june2003/index.shtml (Accessed: 26 September 2013).

May, T. (2012) ‘Qualitative Interviewing: Asking, Listening and Interpreting’, in *Qualitative Research in Action*, pp. 226–241. doi: 10.4135/9781849209656.n10.

Mayer, R. E. and Moreno, R. (2003) ‘Nine ways to reduce cognitive load in multimedia learning’, *Educational Psychologist*, 38(1), pp. 43–52. doi: 10.1207/S15326985EP3801_6.

Mayer, R. E. and Sims, V. K. (1994) ‘For Whom Is a Picture Worth a Thousand Words? Extensions of a Dual-Coding Theory of Multimedia Learning’, *Journal of Educational Psychology*, 86(3), pp. 389–401. doi: 10.1037/0022-0663.86.3.389.

McDonnell, J. (2008) *Constructivist Versus Traditional Math Programs : How Do We Best Meet The Educational Needs Of Our Students ?* Available at: http://digitalcollections.carrollu.edu/cdm/singleitem/collection/edthesis/id/2/rec/15.

Means, B. *et al.* (2009) 'Evaluation of Evidence-Based Practices in Online Learning', *Structure*. Edited by M. Barbara et al. Centre for Learning Technology (Center for Technology in Learning), 15(20), p. 94. Available at: http://newrepo.alt.ac.uk/629/.

Mendicino, M., Razzaq, L. and Heffernan, N. T. (2009) 'A comparison of traditional homework to computer-supported homework', *Journal of Research on Technology in Education*, 41(3), pp. 331–359. doi: 10.1080/15391523.2009.10782534.

Menges, R. *et al.* (2007) 'The ABC transporter Tba of Amycolatopsis balhimycina is required for efficient export of the glycopeptide antibiotic balhimycin', *Applied Microbiology and Biotechnology*, 77(1), pp. 125–134. doi: 10.1007/s00253-007-1139-x.

Michael, R. S. (2004) 'Threats to Internal & External Validity', *Powerpoint*, pp. 1–18. Available at: http://www.indiana.edu/~educy520/sec5982/week_9/520in_ex_validity.pdf.

Miles, M. B. and Huberman, A. (1994) 'Qualitative data analysis: A sourcebook of new methods', 2nd(3), pp. 3–6.

Moore, J. W. (2002) 'Teaching for understanding', *Journal of Chemical Education*, 79(7), p. 775. doi: 10.1021/ed079p775.

Moretti, F. *et al.* (2011) 'A standardized approach to qualitative content analysis of focus group discussions from different countries', *Patient education and counseling*, 82(3), pp. 420–428. doi: 10.1016/j.pec.2011.01.005.

Morgan, C. and Watson, A. (2002) 'The interpretative nature of teachers' assessment of students' mathematics: Issues for equity', *Journal for Research in Mathematics Education*, 33(2), pp. 78–110. doi: 10.2307/749645.

Moustakas, C. (2011) *Phenomenological research methods*, *Phenomenological research methods*. doi: 10.4135/9781412995658.

Muijs, D. (2012) *Doing Quantitative Research in Education with SPSS*, *Doing Quantitative Research in Education with SPSS*. SAGE. doi: 10.4135/9781849209014.

Mukiri, M. I. (2016) *FEASIBILITY OF USING GEOGEBRA IN THE TEACHING AND LEARNING OF GEOMETRY CONCEPTS IN SECONDARY SCHOOLS IN KAJIADO COUNTY, KENYA.*

Murphy, P. (2010) 'Web-based collaborative reading exercises for learners in remote locations: The effects of computer-mediated feedback and interaction via computer-mediated communication', *ReCALL*. UCL, Institute of Education, 22(2), pp. 112–134. doi: 10.1017/S0958344010000030.

Murray, L. *et al.* (2006) ‘Conversations around homework: Links to parental mental health, family characteristics and child psychological functioning’, *British Journal of Developmental Psychology*, 24(1), pp. 125–149. doi: 10.1348/026151005X83568.

Nassaji, H. (2011) ‘Immediate learner repair and its relationship with learning targeted forms in dyadic interaction’, *System*. Elsevier Ltd, 39(1), pp. 17–29. doi: 10.1016/j.system.2011.01.016.

Nathan, A. J. and Scobell, A. (2012) ‘How China sees America’, *Foreign Affairs*, 91(5), pp. 1689–1699. doi: 10.1017/CBO9781107415324.004.

Ncca (2003) ‘Guidelines for Teachers of Students with MILD - General Learning Disabilities’, pp. 1–74. Available at: http://www.ncca.ie/uploadedfiles/P_Mild_Maths.pdf.

NCTM (2014) ‘Procedural Fluency in Mathematics’. Available at: http://www.nctm.org/uploadedFiles/Standards_and_Positions/Position_Statements/ProceduralFluency.pdf.

Nelson Laird, T. F. and Kuh, G. D. (2005) ‘Student experiences with information technology and their relationship to other aspects of student engagement’, *Research in Higher Education*, 46(2), pp. 211–233. doi: 10.1007/s11162-004-1600-y.

Nelson, T. O. (1990) ‘Metamemory: A Theoretical Framework and New Findings’, *Psychology of Learning and Motivation - Advances in Research and Theory*, 26(C), pp. 125–173. doi: 10.1016/S0079-7421(08)60053-5.

Nguyen, D. M. and Kulm, G. (2005) ‘Using Web-based practice to enhance mathematics learning and achievement’, *Journal of Interactive Online Learning*, 3(3). Available at: http://www.ncolr.org/jiol/issues/pdf/3.3.1.pdf (Accessed: 2 September 2013).

Nicholls, M. (2010) ‘Investigation into GCSE students’ self-regulated learning behaviour while doing homework using an internet based online mathematics textbook’.

OECD (2016) *PISA 2015 Results, Excellence and Equity in Ed ucation, Pisa*. Available at: https://ucl-new-primo.hosted.exlibrisgroup.com/primo-explore/fulldisplay.

Ofek, H. (2011) ‘Why the Arabic World Turned Away from Science’, *New Atlantis: A Journal of Technology & Society*, 536, pp. 3–24. Available at: http://ihams.org/index.php (Accessed: 27 July 2013).

Olivier, B. G. and Snoep, J. L. (2004) ‘Web-based kinetic modelling using JWS Online’, *Bioinformatics*, 20(13), pp. 2143–2144. doi: 10.1093/bioinformatics/bth200.

Omlin-Ruback, H. I. (2009) *A study of mathematics homework*, *ProQuest Dissertations and Theses*. Available at: http://medcontent.metapress.com/index/A65RM03P4874243N.pdf (Accessed: 13 August 2013).

Ong'ondo, C. O. and Borg, S. (2011) '"We teach plastic lessons to please them": The influence of supervision on the practice of English language student teachers in Kenya', *Language Teaching Research*, 15(4), pp. 509–528. doi: 10.1177/1362168811412881.

Pajares, F. and Miller, M. D. (1994) '10.1.1.587.2720', *Journal of Educational Psychology*, 86(2), pp. 193–203.

Palocsay, S. W. and Stevens, S. P. (2008) 'A Study of the Effectiveness of Web-Based Homework in Teaching Undergraduate Business Statistics', *Decision Sciences Journal of Innovative Education*, 6(2), pp. 213–232. doi: 10.1111/j.1540-4609.2008.00167.x.

Parmigiani, R. (2012) Using Technology with Classroom Instruction that Works *(review)*, *The Journal of General Education*. doi: 10.1353/jge.2012.0011.

Pascarella, A. (2004) 'The influence of web-based homework on quantitative problem-solving in a university physics class', in *National Association for Research in Science Teaching Annual Meeting*. Available at: http://lon-capa.org/papers/204416ProceedingsPaper.pdf (Accessed: 26 September 2013).

Pasternak, P. C. S. and Whitebread, D. (2014) 'Examining change in metacognitive knowledge and metacognitive control during motor learning: What can be learned by combining methodological approaches?', *Psihologijske Teme*, 23(1), pp. 53–76.

Peng, J. C. (2009) 'Using an online homework system to submit accounting homework: Role of cognitive need, computer efficacy, and perception', *Journal of Education for Business*, 84(5), pp. 263–268. doi: 10.3200/JOEB.84.5.263-268.

Perry, A. B. (2004) 'Decreasing Math Anxiety in College Students.', *College Student Journal*, 38, pp. 321–324. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=507913227&site=ehost-live.

Piaget, J. (2013) *The construction of reality in the child*, *The Construction of Reality in the Child*. doi: 10.4324/9781315009650.

Pimm, D. and Johnston-Wilder, S. (2004) *Teaching secondary mathematics with ICT*, *Learning & Teaching with Information & Communications Technology*.

Pituch, K. A. and Stevens, J. P. (2015) *Applied Multivariate Statistics for the Social Sciences*, *Applied Multivariate Statistics for the Social Sciences*. doi: 10.4324/9781315814919.

Polly, D., Lock, C. and Bissell, B. (2004) 'Mathematical Understanding : Analyzing Student Thought Processes while Completing Mathematical Tasks', *Educational Research*, pp. 535–538.

Porter, T. S. and Riley, T. M. (1996) 'The Effectiveness of Computer Exercises in Introductory Statistics', *Journal of Economic Education*, 27(4), pp. 291–299. doi: 10.1080/00220485.1996.10844920.

Potter, B. N. and Johnston, C. G. (2006) 'The effect of interactive on-line learning systems on student learning outcomes in accounting', *Journal of Accounting Education*, 24(1), pp. 16–34. doi: 10.1016/j.jaccedu.2006.04.003.

Potter, J. (1996) 'Institutional Repository Discourse analysis and constructionist approaches : theoretical background This item was submitted to Loughborough ' s Institutional Repository (https://dspace.lboro.ac.uk/) by the author and is made available under the', pp. 1–11.

Praveen, S. and Leong, K. E. (2013) 'Effectiveness of Using Geogebra on Students ' Understanding in Learning Circles', *The Malaysian Online Journal of Educational Technology*, 1(4), pp. 1–11.

Preiner, J. (2008) *Introducing dynamic mathematics software to mathematics teachers: The case of GeoGebra, Faculty of Natural Sciences University of Salzburg*.

Quirk, B. (2012) *The Truth About Constructivist Math, NCTM*. Available at: http://www.wgquirk.com/ (Accessed: 13 July 2013).

Ravenscroft, A. *et al.* (2012) '21st Century Learning for 21st Century Skills', in *7th European Conference of Technology Enhanced Learning: 21st century learning for 21st century skills*, pp. 113–125. doi: 10.1007/978-3-642-33263-0.

Rayburn, L. G. and Rayburn, J. M. (1999) 'Impact Of Course Length and Homework Assignments on Student Performance', *Journal of Education for Business*, 74(6), pp. 325–331. doi: 10.1080/08832329909601705.

Reese, W. J. (1995) *The Origins of the American High School*. Edited by N. Haven. London: Yale UP, 1995. Print.

Reis, Z. A. and Gulsecen, S. (2010) 'THE EFFECT OF THE GEOGEBRA USE IN MATHEMATICS EDUCATION : A CASE STUDY ON INTEGERS IN TURKEY'.

Rennie, D. L. (2007) 'Methodical Hermeneutics and Humanistic Psychology', *The Humanistic Psychologist*, 35(1), pp. 1–14. doi: 10.1207/s15473333thp3501_1.

Rotter, J. B. (1966) 'Generalized expectancies for internal versus external control of reinforcement.', *Psychological monographs*, 80(1), pp. 1–28. doi: 10.1037/h0092976.

Rousseeuw, P. J. and Hubert, M. (2011) ‘Robust statistics for outlier detection’, *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, 1(1), pp. 73–79. doi: 10.1002/widm.2.

Sadowski, K. (2009) ‘The difference between positive and negative reinforcement’, *Https://Nspt4Kids.Com/Parenting/the-Difference-Between-Positive-and-Negative-Reinforcement/*, pp. 1–20. Available at: https://pdfs.semanticscholar.org/2cb0/b3019f04cfbf790d0ed8fa39f603bcfa4f7e.pdf.

Saha, R. A., Ayub, A. F. M. and Tarmizi, R. A. (2010) ‘The effects of GeoGebra on mathematics achievement: Enlightening Coordinate Geometry learning’, *Procedia - Social and Behavioral Sciences*, 8(May 2016), pp. 686–693. doi: 10.1016/j.sbspro.2010.12.095.

Santhanam, R., Sasidharan, S. and Webster, J. (2008) ‘Using Self-regulatory learning to enhance E-Learning-Based information technology training’, *Information Systems Research*, 19(1), pp. 26–47. doi: 10.1287/isre.1070.0141.

Sartawi, A. *et al.* (2012) ‘Predicting Mathematics Achievement by Motivation and Self-Efficacy across Gender and Achievement Levels.’, *Interdisciplinary Journal of Teaching and Learning*, 2(2), pp. 59–77. Available at: http://www.fedu.uaeu.ac.ae/research/doc/Motivation and Self-Efficacy..pdf (Accessed: 24 November 2013).

Scheeler, M. C., McKinnon, K. and Stout, J. (2012) ‘Effects of Immediate Feedback Delivered via Webcam and Bug-in-Ear Technology on Preservice Teacher Performance’, *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children*, 35(1), pp. 77–90. doi: 10.1177/0888406411401919.

Schmitz, B. and Perels, F. (2011) ‘Self-monitoring of self-regulation during math homework behaviour using standardized diaries’, *Metacognition and Learning*, 6(3), pp. 255–273. doi: 10.1007/s11409-011-9076-6.

Schneider, W. and Artelt, C. (2010) ‘Metacognition and mathematics education’, *ZDM - International Journal on Mathematics Education*, 42(2), pp. 149–161. doi: 10.1007/s11858-010-0240-2.

Schumacher, H. R. *et al.* (2008) ‘Effects of febuxostat versus allopurinol and placebo in reducing serum urate in subjects with hyperuricemia and gout: A 28-week, phase III, randomized, double-blind, parallel-group trial’, *Arthritis Care and Research*, 59(11), pp. 1540–1548. doi: 10.1002/art.24209.

SIMON, H. A. (1967) ‘Motivational and Emotional Controls of Cognition’, *Psychological Review*, 74(1), pp. 29–39. doi: 10.1037/h0024127.

Sitzmann, T. *et al.* (2008) *A Multilevel Analysis of the Effects of Technical Interruptions on Learning and Attrition From Web-Based Instruction*. Available at: http://digitalcommons.ilr.cornell.edu/cahrswp/490.

Skemp, R. R. (2020) ‘Relational Understanding and Instrumental Understanding’, *Mathematics Teaching in the Middle School*, pp. 88–95. doi: 10.5951/mtms.12.2.0088.

Skinner, B. F. (1950) ‘Are theories of learning necessary?’, *Psychological Review*, 57(4), pp. 193–216. doi: 10.1037/h0054367.

Smith, D. (2009) ‘Closing the Achievement Gap Report for 21st Century Learners in West Virginia. 2009-2010.’, *West Virginia Department of Education*. Available at: http://medcontent.metapress.com/index/A65RM03P4874243N.pdf%0Ahttp://www.eric.ed.gov/ERICWebPortal/recordDetail (Accessed: 30 June 2013).

Smith, P. B., Trompenaars, F. and Dugan, S. (1995) ‘The Rotter Locus of Control Scale in 43 Countries: A Test of Cultural Relativity’, *International Journal of Psychology*, 30(3), pp. 377–400. doi: 10.1080/00207599508246576.

Sommerville, M. (2015) *Info@Cie.Org.Uk*, *Cambridge International Examinations*. Available at: https://www.cambridgeinternational.org/Images/272307-metacognition.pdf.

Song, J. H. and Thompson, L. (2011) ‘Ji Hoon Song, PhD’, 24(3), pp. 55–76. doi: 10.1002/piq.

Strauss, S. (1993) ‘Teachers’ Pedagogical Content Knowledge About Children’s Minds and Learning: Implications for Teacher Education’, *Educational Psychologist*. International Society for Technology in Education. 180 West *th Avenue, Suite 300, Eugene, OR 97401-2916. Tel: 800-336-5191; Tel: 541-302-3777; Fax: 541-302-3778; e-mail: iste@iste.org; Web site: http://www.iste.org, 28(3), pp. 279–290. doi: 10.1207/s15326985ep2803_7.

Suriyon, A., Inprasitha, M. and Sangaroon, K. (2013) ‘Students ’ Metacognitive Strategies in the Mathematics Classroom Using Open Approach’, 4(7), pp. 585–591.

Tang, G. and Titus, A. (2002) ‘Increasing students’ time on task in calculus and general physics courses through WebAssign’, *Proceedings of the 2002 ASEE Conference and …*, pp. 1–24. Available at: http://scholar.google.com/scholar (Accessed: 31 December 2013).

Tarmizi, R. A. *et al.* (2010) ‘Effects of Technology Enhanced Teaching on Performance and Cognitive Load in Calculus’, 4(2), pp. 109–120.

Tat, T. B. and Fook, F. S. (2005) ‘The Effects of Geometer’s Sketchpad and Graphic Calculator in the Malaysian Mathematics Classroom’, *Malaysian Online Journal of Instructional Technology*, 2(2), pp. 82–96.

Thambi, N. and Eu, L. (2013) ‘Effect of students’ achievement in fractions using geogebra’, *Sainsab*, 16, pp. 97–106. Available at: http://umexpert.um.edu.my/file/publication/00010213_95273.pdf.

Thurlings, M. *et al.* (2013) ‘Understanding feedback: A learning theory perspective’, *Educational Research Review*. Elsevier Ltd, 9, pp. 1–15. doi: 10.1016/j.edurev.2012.11.004.

Thurstone, L. L. (1948) ‘Thurstone, L. L. Multiple-factor analysis. Chicago: University of Chicago Press, 1947, pp. 535. $7.50’, *Journal of Clinical Psychology*, 4(2), pp. 224–224. doi: 10.1002/1097-4679(194804)4:2<224::aid-jclp2270040225>3.0.co;2-7.

Toback, D., Mershin, A. and Novikova, I. (2005) ‘A Program for Integrating Math and Physics Internet-Based Teaching Tools into Large University Physics Courses’, *Program*, pp. 594–597. Available at: http://arxiv.org/abs/physics/0505026.

Trautwein, U. (2007) ‘The homework-achievement relation reconsidered: Differentiating homework time, homework frequency, and homework effort’, *Learning and Instruction*, 17(3), pp. 372–388. doi: 10.1016/j.learninstruc.2007.02.009.

Trautwein, U. and Köller, O. (2003) ‘The Relationship between Homework and Achievement - Still Much of a Mystery’, *Educational Psychology Review*, pp. 115–145. doi: 10.1023/A:1023460414243.

Trautwein, U., Lüdtke, O. and Pieper, S. (2007) *Learning Opportunities Provided by Homework (HALO) | Max Planck Institute for Human Development*. Available at: https://www.mpib-berlin.mpg.de/en/research/concluded-areas/educational-research/research-area-i/homework-halo.

Vinet, L. and Zhedanov, A. (2011) ‘A “missing” family of classical orthogonal polynomials’, *Journal of Physics A: Mathematical and Theoretical*, 44(8), pp. 275–322. doi: 10.1088/1751-8113/44/8/085201.

Walberg, H. J., Paschal, R. A. and Weinstein, T. (1985) ‘Homework’s Powerful Effects on Learning’, *Educational Leadership*, pp. 76–79. Available at: http://www.ascd.org/ASCD/pdf/journals/ed_lead/el_198504_walberg.pdf.

Walsh, I. *et al.* (2015) ‘What Grounded Theory Is…A Critically Reflective Conversation Among Scholars’, *Organizational Research Methods*, 18(4), pp. 581–599. doi: 10.1177/1094428114565028.

Watershed (2011) *MyMaths - Watershed PR*, *Newsletter*. Available at: http://watershedpr.co.uk/2011/06/mymaths-2/.

Welford, W. T. (1979) ‘Chapter 9. Gradient Index Optics’, *Optica Acta: International Journal of Optics*, 26(4), pp. 426–427. doi: 10.1080/713820027.

Werts, M. G. *et al.* (1995) ‘Instructive feedback: Review of parameters and effects’, *Journal of Behavioral Education*, 5(1), pp. 55–75. doi: 10.1007/BF02110214.

Wicks, D. (2017a) *The Coding Manual for Qualitative Researchers (3rd edition)*, *Qualitative Research in Organizations and Management: An International Journal*. doi: 10.1108/qrom-08-2016-1408.

Wicks, D. (2017b) *The Coding Manual for Qualitative Researchers (3rd edition)*, *Qualitative Research in Organizations and Management: An International Journal*. doi: 10.1108/qrom-08-2016-1408.

Wigfield, A. and Meece, J. L. (1988) 'Math Anxiety in Elementary and Secondary School Students', *Journal of Educational Psychology*, 80(2), pp. 210–216. doi: 10.1037/0022-0663.80.2.210.

Wilkins, J. L. M. and Ma, X. (2003) 'Modeling change in student attitude toward and beliefs about mathematics', *Journal of Educational Research*, 97(1), pp. 52–63. doi: 10.1080/00220670309596628.

Wooten, T. and Dillard-Eggers, J. (2016) 'An Investigation Of Online Homework: Required Or Not Required?', *Contemporary Issues in Education Research (CIER)*, 6(2), p. 189. doi: 10.19030/cier.v6i2.7728.

Wright, D. E. and Miller, L. D. (1981) 'Math Anxiety: A Research Report.', (1). Available at: http://eric.ed.gov/?id=ED212465.

Yee, H. T. K. *et al.* (2009) 'A review of the literature: Determinants of online learning among students', *European Journal of Social Sciences*, 8(2), pp. 246–252.

Zerr, R. (2007) 'A Quantitative and Qualitative Analysis of the Effectiveness of Online Homework in First-Semester Calculus', *Journal of Computers in Mathematics and Science Teaching*, 26(1), pp. 55–73.