# The Impact of Using Information and Communication Technology in the Attitudes and Achievement of Grade Three Students in Mathematics and Science

# أثر استخدام تكنولوجيا المعلومات والاتصالات في اتجاهات وتحصيل طلبة الصف الثالث في الرياضيات والعلوم

**by**


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# Abstract

Nowadays, Information and Communication Technology (ICT) plays an important role in transforming and supporting the learning process. Thus, the need to understand how the investment in educational technology can impact teaching and learning practices becomes apparent. According to the studies, evidence shows that some school subjects benefit from ICT more than others. This study aimed to explore the impact of ICT use in mathematics and science classes by investigating the effect of such integration on grade-three students' attitudes towards ICT use, and their achievement in mathematics and science.

The participants of this study comprised of 41 grade-three students from a private school in Dubai. Students were divided into two groups; an experimental group where an ICT tool was used for instruction, and a control group where the teacher was the source of instruction. A mixed-method approach was used to collect data via students' attitudes questionnaire, pre- and post-achievement tests, and classroom observations.

Data analysis of attitudes questionnaire has revealed that students have positive attitudes towards the use of ICT in the computer lab in both mathematics and science. However, students were found to enjoy the science class more than mathematics when using ICT. The analysis of pre- and post- achievement tests revealed that the use of ICT increased students' achievement scores in both subjects. But when compared to the traditional method of teaching, this impact was not considered statistically significant. When comparing students' progress in mathematics and science when using ICT, science was found to benefit from ICT more than mathematics. The findings of the observation reflected students' confusion at the beginning of the class and their need for clear instructions. Additionally, students needed the teacher's help in some parts of the lessons, especially in mathematics, indicating that the teacher should stay central of the education process. These findings imply that in order to best benefit from ICT in classroom, pedagogies as well as CAI design should be further investigated.

## ملخص

في الوقت الحاضر، تلعب تكنولوجيا المعلومات والاتصالات دورا هاما في تحويل ودعم عملية التعلم. وبالتالي فإن هناك حاجة ماسة إلى فهم مدى تأثير الاستثمار في التكنولوجيا التعليمية على ممارسات التعليم والتعلم. وفقا للدراسات فإن هناك أدلة على أن بعض المواد الدراسية تستفيد من تكنولوجيا المعلومات والاتصالات أكثر من غيرها. يهدف هذا البحث إلى دراسة أثر استخدام تكنولوجيا المعلومات والاتصالات في فصول الرياضيات والعلوم من خلال دراسة تأثير هذا الاستخدام على اتجاهات طلاب الصف الثالث نحو استخدام تكنولوجيا المعلومات والاتصالات، بالإضافة إلى تأثيره في تحصيلهم في الرياضيات والعلوم.

شارك في هذه الدراسة 41 طالبا من الصف الثالث من مدرسة خاصة في دبي. تم تقسيم الطلاب إلى مجموعتين: مجموعة تجريبية حيث كانت تكنولوجيا المعلومات والاتصالات تستخدم كأداة للتعليم، ومجموعة السيطرة حيث كان المعلم مصدر التعليم. وقد تم استخدام منهجية مختلطة الأسلوب لجمع البيانات الكمية والنوعية من خلال استخدام استبيان لاتجاهات الطلبة، واختبارات ما قبل وبعد التحصيل، ومشاهدة الفصول الدراسية.

وقد كشف تحليل بيانات استبانة الاتجاهات أن لدى الطلبة اتجاهات إيجابية تجاه استخدام تكنولوجيا المعلومات والاتصالات في مختبر الحاسوب في مادتي الرياضيات والعلوم بشكل عام. أما عند مقارنة اتجاهات الطلاب في المادتين، فقد وجد أن الطلاب يستمتعون في حصة العلوم أكثر من حصة الرياضيات عند استخدام الحاسوب. وأظهر تحليل اختبارات ما قبل وبعد التحصيل أن استخدام تكنولوجيا المعلومات والاتصالات زاد من درجات تحصيل الطلبة في الرياضيات والعلوم. ولكن بالمقارنة مع الطريقة التقليدية للتدريس، لم يكن هذا التأثير ذو دلالة إحصائية. أما عند مقارنة تقدم الطلبة في الرياضيات والعلوم عند استخدام تكنولوجيا المعلومات والاتصالات، فقد أظهر التحليل أن مادة العلوم استفادت أكثر من تكنولوجيا المعلومات والاتصالات مقارنة بمادة الرياضيات. ولقد أجريت عملية مشاهدة الطلاب في مختبر الحاسوب للتحقق من صحة نتائج التحليل الكمي والمساعدة في تبريرها. فقد لوحظ ارتباك الطلاب في بداية الدرس وحاجتهم إلى تعليمات واضحة من المعلم. بالإضافة إلى ذلك، كان الطلاب بحاجة إلى مساعدة المعلم في بعض أجزاء الدروس خاصة في الرياضيات، مما يشير إلى أن دور المعلم يجب أن يبقى مركزيا في عملية التعليم. وتشير هذه النتائج إلى أنه للاستفادة على أفضل وجه من تكنولوجيا المعلومات والاتصالات في الفصول الدراسية، ينبغي إجراء مزيد من الدراسات في أساليب التدريس باستخدام تكنولوجيا المعلومات والاتصالات بالإضافة إلى دراسة تصميم برامج الحاسوب المستخدمة في التعليم.

# Dedication

This work is firstly dedicated to my parents, who have planted in me the love of reading and grew me thirsty for knowledge. *I wouldn't be who I am today without you.*

A special feeling of gratitude for my beloved husband for believing in me and supporting me throughout my life. *I wouldn't be where I am today without you.*

Finally, I lovingly dedicate this work to my children Malak, Jana, Saif and Yousef for making sure mama learns how to multitask and work in a "perfect" atmosphere of crying, nagging, laughing, and most of all, joy. *I wouldn't dream as I do today without you.*

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I would also like to thank my dear husband for giving his time to proofread my thesis as well as supporting me all the way.

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## List of Abbreviations

| Abbreviation | Description |
|---|---|
| ADEC | Abu Dhabi Education Council |
| ANOVA | Analysis of Variance |
| CAI | Computer Assisted Instruction |
| CAL | Computer Assisted Learning |
| CBL | Computer Based Learning |
| CG | Control Group |
| DF | Degrees of Freedom |
| DSIB | Dubai School Inspection Bureau |
| EFA | Exploratory Factor Analysis |
| EG | Experimental Group |
| ICT | Information and Communication Technology |
| ILE | Interactive Learning Environment |
| M | Mean |
| N | Sample Size |
| NEASC | New England Association of Schools and Colleges |
| OECD | Organization for Economic Cooperation and Development |
| PC | Personal Computer |
| PDA | Personal Digital Assistant |
| PISA | Programme for International Students Assessment |
| SD | Standard Deviation |
| SPSS | Statistical Package for the Social Sciences |
| UAE | United Arab Emirates |
| UK | United Kingdom |

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# 1. Chapter One:
# Introduction

Computers can be a valuable instructional tool when used under the right conditions. In a perfect setting, teachers have the needed knowledge to use computers in the classroom, enough equipment is available to accommodate all the students allowing them enough time to complete tasks, and teachers assume a student-centred and constructivist pedagogy (Becker 2000). Researchers, educators, and policy makers are all interested in measuring and understanding how educational technology can change teaching practices as well as how students learn. Even though the process of measuring the changes in educational practices and students learning outcomes is time-consuming, this process in essential for assessing the effectiveness of computers in education as well as developing better tools (Balanskat, Blamire & Kefala 2006).

## 1.1. Background and Motivation

ICT can contribute to the development and prosperity of a nation by providing wider access to education, better learning and teacher quality, advanced professional development for teachers, and a more efficient school management system.

Governments all over the world have understood the importance of ICT in education and invested in schools by providing equipment, online access and internal networks, and ICT professional development for teachers. At the same time, governments and private schools' owners believe that they have the right to know whether ICT initiatives have been fruitful and whether these technological tools improved students' performance at schools. Such evaluation provides insights for future ICT strategies and policies and offers direction for actions and budget aims (Balanskat, Blamire & Kefala 2006).

My work on this research is influenced by my background as an ICT coordinator in a private school. As part of my job, I coordinate the use of computer labs between all subjects, including science, mathematics, English, Arabic as well as computer classes. Even though the school I work at comprises of many computer labs distributed among the school, the demand of head of subjects as well as teachers is huge that I have to spend a considering amount of time fixing timetables and, sometimes, creating alternate week schedules trying to accommodate all classes for all subjects in the available time slots in the computer lab. My main motivation for choosing this research project was to investigate whether some school subjects benefit from ICT more than others. Having in mind that ICT resources, however abundant, may be limited to serve all teachers' educational plans, it becomes of importance to know the extent of the effect ICT on students learning outcomes and experiences in different school subjects at different levels.

Obtaining such information can be useful at various levels. For instance, if the investment in ICT is working with some school subjects and not with others, policy makers and stakeholders may think of shifting the direction of the investment to those specific school subjects or levels (i.e. English in primary school) where results are positive. On the other hand, we could use this information to understand what are the practices or settings that are making ICT more useful in a subject rather than another. Or, it may lead us to think that the way ICT is used with a subject cannot be projected to other subjects.

Previous studies suggest that ICT impacts most in primary than in middle or high schools. Additionally, it was found that the highest impact occurred when ICT was used with first language studies (i.e. English), and less so in science and not in mathematics (Harrison et al. 2002; Balanskat, Blamire & Kefala 2006; Machin, McNally & Silva 2006). These studies were conducted in European countries as a way to measure whether the investment in ICT in schools had paid off and to understand what affects the digital disadvantage in some subjects.

In this paper, I have chosen to evaluate how the two subjects, mathematics and science, in a school setting, benefit from the use of ICT, particularly in the computer lab. The reason these two subjects were chosen was because of the similarities in the interactive software used in the computer lab for both subjects. Additionally, both subjects have the same frequency of computer lab visits per week as well as a consistency of visits throughout the year.

### 1.2. Aim and Objectives

The main aim of the current study is to identify the effect of using ICT in the achievement and attitudes of grade three students in mathematics and science, through achieving the following objectives:

1. Identify the attitudes of grade three students towards the use of ICT in the studying of mathematics and science.

2. Investigate the differences in the attitudes of grade three students between mathematics and science using ICT.
3. Investigate the differences in the mathematics subject between the average achievement of grade three students using ICT and without.
4. Investigate the differences in the science subject between the average achievement of grade three students using ICT and without.
5. Investigate the differences in the achievement of grade three students between mathematics and science using ICT.

## 1.3. Research Questions

Based on the aim of the research, this paper tries to answer the following primary question:

**Is there a difference in the impact of ICT on students' attitudes and achievement between mathematics and science subjects?**

To answer the primary research question, this paper tries to answer the following secondary questions:

**Research Question 1:** What are the attitudes of the grade three students towards the use of ICT in the studying of mathematics and science?

**Research Question 2:** Is there a difference in the attitudes of grade three students towards the use of ICT between mathematics and science subjects?

**Research Question 3:** Is there a difference in the mathematics subject between the average achievement of grade three students using ICT and without?

**Research Question 4:** Is there a difference in the science subject between the average achievement of grade three students using ICT and without?

**Research Question 5:** Is there a difference in the achievement of grade three students between mathematics and science using ICT?

## 1.4. Hypotheses

Research hypotheses are formulated to predict a relationship between variables in the study (Greene & d'Oliveira 2005). This study aims to test the following hypothesis:

**$H_{A1}$:** There is a significant relationship at level ($\alpha \leq 0.05$) in students' use of ICT and their attitudes towards it.

**$H_{A2}$:** There is a significant difference at level ($\alpha \leq 0.05$) in the attitudes of grade three students towards the use of ICT between mathematics and science subjects.

**$H_{A3}$:** There is a significant difference at level ($\alpha \leq 0.05$) in the mathematics subject between the average achievements of grade three students' using ICT and without.

**$H_{A4}$:** There is a significant difference at level ($\alpha \leq 0.05$) in the science subject between the average achievements of grade three students' using ICT and without.

**$H_{A5}$:** There is a significant difference at level ($\alpha \leq 0.05$) in the average achievement of grade three students between mathematics and science using ICT.

In psychology research, it is fitting to accept a probability of 5 per cent ($\alpha \leq 0.05$) as bases to reject the null hypothesis. That is to say that in this study, the probability of the results to be due to random variability is 5 per cent or less (Greene & d'Oliveira 2005).

## 1.5. Significance of the Research

The Ministry of Education in the United Arab Emirates (UAE) recognized the importance of education and has designed a set of elaborated plans to improve the quality of teaching and learning. The government is prepared to invest in the educational system by ensuring all schools are equipped with smart systems and devices that support the education process (UAE Government 2017). An example of the initiatives includes The Mohamad bin Rashid Smart Learning Program that aims to provide students with smart tablets and high-speed connectivity as well as e-content for all subjects (Pennington 2014). Another example is The Abu Dhabi Education Council (ADEC) promise to supply schools with virtual reality tools and digital content (ADEC 2015). Additionally, private schools' owners in the UAE believe that investing in technology in their schools will increase their returns and provide better education quality.

With the believe that ICT can help improve students' outcomes, studying the specific impact of ICT on different subjects can prove vital. As educators, we always aim to utilize class time as effectively and efficiently as possible. Thus, knowing what technological tools best support each school subject as well as the most effective pedagogy to use when integrating ICT is essential. Additionally, studying the impact of ICT investment on students learning outcomes would help policy makers and school owners decide where this financing should be directed and what are the best practices and settings that aid the positive impact of ICT. This information is helpful in developing the optimal schooling environment to reimburse ICT investment.

Many studies report the importance of ICT and its impact on different school subjects and at different school levels. For example, Babateen (2011) points out that one of the most significant advantages of using ICT in science learning is that it facilitates the study of many scientific phenomena that cannot be done in the science laboratory due to their danger or cost. Similarly, Condie and Munro (2007) described how animations and simulations improved students' understanding in mathematics by providing graphical illustrations of abstract concepts and procedures that may not be possible using traditional teaching resources. However, while there is abundant research on ICT impact on each school subject separately, studies comparing the different impact ICT has on each subject are still insufficient.

Cox et al. (2003) performed an extensive literature review regarding ICT and attainment and found that ICT impact was stronger when ICT was used to support language acquisition and specific concepts in Math and Science. Likewise, a comprehensive study on ICT use in UK schools revealed that, when using ICT, students performed better in English and science but not in mathematics (Harrison et al. 2002). Similarly, a wide-ranged study showed that ICT investment in schools pays off the most on English subject, less on science, and not in mathematics (Machin, McNally & Silva 2006). However, there is still a need for more experimental studies that compare the impact of ICT in different school subjects.

This study aims to support students' benefit from ICT in mathematics and science by providing insights on how each subject best benefit from ICT.

## 1.6. Dissertation Structure

This dissertation is divided into five chapters. This chapter has provided a summary of the background and motivation behind this study as well as an outline of the objectives, research questions of the study as well as its significance, and the expected hypothesis.

Chapter two defines the key theories underlying this study. It also explores the literature related to the role and impact of ICT in education as well as its specific role in mathematics and science subjects. It also covers the uses of specific technologies in the classroom and how they contribute to students' general achievement and attitudes towards the taught subjects. Finally, it reviews the approaches used to measure students' achievement and attitudes as well as the related studies.

Chapter three describes the research methodology of the research by providing details on the procedures, design, participants, context, and ethical considerations. It also provides detailed description of research instruments as well as the rationale behind choosing them, their validation and reliability, and suggested analysis plan.

Chapter four presents the findings and analysis of the quantitative and qualitative instruments data in order to answer the research questions and test the hypotheses. Discussion of the results is presented after each research question.

Finally, chapter five portrays the conclusion of this research, providing a summary of the study, recommendation, implications, limitations, and the scope for further study.

# 2. Chapter Two:
# Theoretical Background and Literature Review

This chapter defines the key theories underlying this study. It also explores the literature related to the role and impact of ICT in education as well as its specific role in mathematics and science subjects. It also covers the uses of specific technologies in the classroom and how they contribute to students' general achievement and attitudes towards the taught subjects. Finally, it reviews the approaches used to measure students' achievement and attitudes as well as the related studies.

## 2.1. Conceptual Analysis

This study aims to study the impact of ICT on a school subject by studying three main concepts related to ICT as a pedagogical tool; students' attitudes towards the use of ICT, the design of the ICT tool considering learning theories, and teachers' pedagogies.

Attitudes can be described as psychological inclination that evaluates a particular subject with some degree of approval or disapproval. In general, they are the negative or positive views regarding an idea, situation or object and how a person responds to them. Attitudes in education are formed as a result of going through an experience or a situation in teaching or learning. Attitudes consist of three main components; cognitive, affective, and behavioural. What a person believes or thinks about an object is what we call a cognitive component. The feelings associated with an object are called affective components. The way a person responds to or behaves towards an object is called the behavioural component (Mensah, Okyere & Kuranchie 2013). When using ICT as a method of instruction, the way it is designed should positively affect students believes and feelings towards this use, and therefore, increase students' benefit from the tool.

Students learn in various forms and with varying degrees of success. For example, students can learn through reading, memorizing, solving problems, observing, watching and listening to videos, and by experimenting with things. Software designers could use different techniques to display information and organize content such as mnemonics and chunking to increase knowledge retention. Additionally, educational software includes many opportunities for practice which increases the efficient use of memory (Crews 2004). Additionally, interactive software or web-pages such as virtual reality programs and simulation can support constructive learning by providing an environment where the student can interact with virtual objects, observe results in real time, and learn through investigation through hands-on activities. Moreover, ICT software should follow an instructional pattern where learning is divided into progressive sequences of small activities that cover a particular skill. The software plays the role of the teacher by offering 'drill and practise' activities followed by prompt feedback on student' work (Pachler 2001). Most of the computer-assisted learning (CAL) software is based on the behaviourists learning theories since they emphasize on repeating material to students giving them more chance for practice. They also allow students to study at their own pace by presenting individualized material. However, a danger of such software is when students assume a 'passive mentality' where they do not think about the questions and rather use a trial and error approach to reach the right answer (Prescott 2001).

Existing literature suggests that the integration of ICT in schools is rather marginal and does not alter the teacher's pedagogies despite government huge investments in technology. Previous research showed that teacher's planning plays an important role in the successful incorporation of ICT in education. However, it was found that teacher's training usually focuses on how to use ICT tools rather than focusing on how to use those tools to improve learning. Therefore, the use of ICT should be driven by the demands of pedagogy of a particular subject matter (Jimoyiannis et al. 2013)

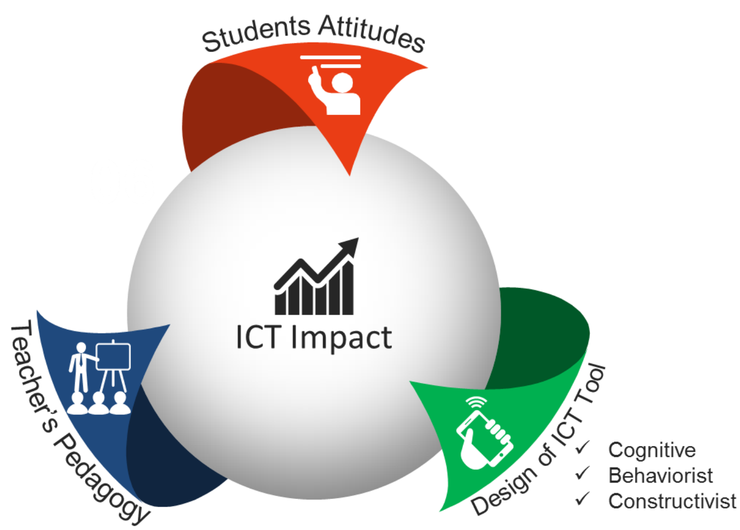


*Figure 1: Factors Considered in the Study to Evaluate the Impact of ICT*

## 2.2. Theoretical Framework

In order to study ICT's role in students' attitudes towards a school subject and their achievement, this research relies on three main learning theories; Cognitive Psychology, Constructivism and Behaviourism.

Attitudes are formed according to three different learning theories of behaviourism; classical conditioning, operant conditioning, and observational learning. This study is concerned of Skinner's operant conditioning theory where a positive reinforcement increases the possibility of a repeated behaviour. Skinner suggested that learning can be more effective if the environment is carefully controlled. Students receiving prompt and positive feedback are more likely to enjoy the activity, and therefore, be willing to repeat the behaviour (Mensah, Okyere & Kuranchie 2013).

Cognitive psychologists like Piaget argue that learning is a process that cannot be observed directly. Cognitive theories of learning, such as the information-processing theory, emphasize on the ability to process, store and retrieve knowledge in the mind. The constructivist theory is based on the notion that students should 'construct' their knowledge by relating their previous knowledge with an interactive environment. Piaget and Vygotsky both emphasized that cognitive change occurs when previous knowledge goes through a process of disequilibration when students encounter a new situation that does not match what they previously know. In a constructivist setting, the pedagogy shifts from teacher-cantered to a more students-centred approach where the teacher role is more of a facilitator. Teachers guide students through the process of learning by making the situations more relevant to students experience and helping them be aware of their approaches to learning. On the other hand, behaviourists believe that learning is a process of condition in which the students are exposed to positive or negative stimulus and where their responses are rewarded or penalized according to their correctness. As opposed to cognitive theories, behavioural learning theories rely on observable actions (Slavin 2012).

Therefore, how students construct knowledge using ICT is a combination of behavioural and cognitive theories. Teachers as well as educational software can demonstrate new concepts to students. Students then practice those new concepts and receive feedback. Beliefs and attitudes are similarly emphasized by cognitive theories. How students perceive their learning and capabilities in a specific subject directly affect their performance. Teachers therefore need to consider students' attitudes when planning their lesson (Schunk 2012).

## 2.3. ICT as a Pedagogical Tool

Since the introduction of personal computers in the '80s, a wide range of applications and technologies became available to be used in educational contexts. Educational ICT tools include any hardware or software that can be integrated in teaching and learning as a source of information. This includes projectors, whiteboards, laptops, tablets, and visualizers, to name a few (Ziden et al. 2011).

One of the main educational technology terms introduced is the Computer Assisted Instruction (CAI). CAI can be defined as the use of a computer based learning model to present information to the learners, assess their understanding through a set of questions, and provide immediate feedback (Kahveci & Imamoglu 2007). The use of CAI can be divided into two main categories; the use of technology to provide educational concepts that are impossible to deliver otherwise, such as programming and augmented instruction, and to use technology to replace traditional teaching methods, such as online tutorials and computer-based assessment (Lipson & Smith 2013). Other terms that are often used interchangeably with CAI are Computer Assisted Learning (CAL), Computer Based Learning (CBL), and Interactive Learning Environment (ILE).

CAI is considered a useful technology tool specially when it is built on a specific learning approach. The benefits of CAI are based on the ability of such tools to adapt to learners' differences by providing various means of presentations (pictures, sounds and videos) and the ability to provide instant feedback to students and give them control over their learning (Kahveci & Imamoglu 2007).

As the role of ICT in improving students' attitudes and motivation becomes more apparent, the need for a framework for designing effective CAI increases. Researchers suggest that in order to design effective CAI to improve learning, it is important to comprehend the whole educational context (Salomon 1990). Learning is physical and psychological change that alters the student's behaviour or mental capability. Mastering knowledge and skills usually occurs after a cognitive effort by the student through different types of learning processes such as habit formation and episodic memory of events (Crews 2004).

According to Dick, Carey and Carey (2005), there are four essential interconnected factors in any instructional setting; the learners, the learning objective, instructional material, and the learning environment. The instructional design directly impacts the quality of learning, and therefore, aids the achievement of the learning objectives. It is essential to consider how learning happens in order to design an educational software that supports the learner (Crews 2004). According to constructivists' theories, learning occurs when the learner is engaged in active participation and cognitive thinking. When the learner involves in a mental activity, he is exhausting a part of his finite working memory used to process information, and therefore, reducing the available resources for simultaneous tasks. In order to increase the learning benefits of a task, it is essential to reduce distractions and irrelevant information to free up memory resources for learning (Slavin 2012). CAI should be designed to support students' active participation by engaging them in interactive tasks, assessment and feedback. Additionally, the CAI design should direct students' attention to relevant information while minimizing unrelated distraction. This can be done by providing short tasks accompanied by prompt feedback (Crews 2004).

Another important issue to consider is how students learn through their senses in what is known as Multisensory Learning. Students have different learning styles; visual, auditory, and kinaesthetic. However, it has been suggested that processing information through multiple modes reinforces the development of learners' mental models and increases the capacity of the working memory to process more information simultaneously. An example of this in a CAI tool is the use of an audio clarification of an on-screen diagram. It is therefore important to design a CAI that supports students' perceptual preferences without overloading their cognitive capacity (Crews 2004).

Moreover, the differences among low and high ability learners should be pondered by considering the order of presenting the learning material. For example, high ability learners can be presented with an example or problem and be allowed to utilized their previous knowledge to draw conclusions in what is known as inquiry or discovery based learning. By contrast, it is more beneficial for low ability learners to directly present them with the knowledge and then provide them with activities to apply that knowledge in what is known as expository learning. It is believed that a CAI tutorial is more beneficial when applying expository learning methods by providing structured instruction based on the learning objectives (Crews 2004). Additionally, mastery learning denotes that a student should master a particular skill to a predefined mastery criterion level before advancing to the next skill. When working on a classroom setting, the teacher needs to spend additional time with low ability students in order to get them to the mastery level needed

(Slavin 2012). A well-designed CAI can overcome this disadvantage by providing personalized learning and allowing the students to progress at their own pace (Crews 2004).

Assessment is another important component of any instructional setting where students acquisition of learning objectives is evaluated. Assessment must be accompanied by appropriate feedback for more effective learning. Therefore, remedial Feedback is considered an important element of the learning process as it facilitates students' evaluation of their cognitive models. Feedback should be instantaneous and precise in order to be effective. Feedback should not only provide the student with knowledge about the rightness of the answer, but should also provide them with a descriptive account on their work. In a classroom setting, it is impossible for the teacher to provide immediate one-on-one feedback to all the students as they progress through their work. One of the main benefits of using CAI is that it provides immediate and personalized feedback to each student according to their performance. Additionally, it has been found that students with high self-consciousness benefit more from computer-mediated feedback rather than person-mediated feedback (Crews 2004).

When designing a CAI tool, all the previous components of the instructional design should be taken into consideration, including the learner, the learning objectives, the instructional materials, and the learning environment. Additionally, the CAI can be personalized by including the student's name in different components of the lesson, such as the instructions and feedback. Moreover, the tool should be personalized to meet the student's needs. These forms of personalization have been found to positively impact students' achievement and motivation (Crews 2004). Moreover, a successful learning environment should include essential components such as navigation, motivation and interaction. Navigation refers to the students' ability to see how content is organized, navigate through content, and correct themselves if needed. The motivation element denotes that learning environments should be interesting and simulating to students. Finally, interaction refers to real-life problems that challenge students' cognitive abilities (Merrill 2002).

## 2.4. ICT Impact in Specific Subject Areas

According to the studies, evidence shows that some school subjects benefit from ICT more than others. The greater impact has been seen in English and foreign languages, science, geography, and mathematics. The availability of online information, video conferences, and photography have influenced learning modern languages and improved communication skills among students. Similarly, 3D animations and simulations and digital microscopes have allowed students to clasp complex and abstract concepts in science and math. Additionally, history can benefit from learning objects and geography from geographical information systems (GIS). However, most of the research studying the impact of ICT on specific subjects are small-scale studies and, therefore, further research is required to study long term impact and whether such results can be applied in different situations (Condie & Munro 2007).

### 2.4.1. ICT in Science

In order to engage students in science, courses should be designed to involve students in activities that imitate real life experiences by teaching them how to search for reliable information and find solutions to daily problems, which are considered the main objectives of science teaching. For example, when students engage in laboratory tasks by preparing the experiment and observing and discussing results, they become active learners which helps them grasp abstract concepts and link them to real life. Many countries believe that experimental lab activities build students' knowledge and improve their understanding of science concepts and, therefore, encourage their teachers to engage their students in such activities (Park, Khan & Petrina 2009).

ICT provides many tools and applications that can benefit science as a school subject. These tools include for example, virtual labs, data capture and logging tools, simulators, databases and spreadsheets, graphing tools, presentation tools, and digital microscopes. Condie and Munro (2007) suggest that ICT can make science a more exciting and relevant subject for students. They also suggest that using ICT in the lab spares more time for the experiment's analysis and discussion, and therefore, fosters communication and collaboration.

In their study of the ICT literature in relation to science, Osborne and Hennessy (2003) point out the potential influence of technology on science curriculum and pedagogy. ICT was found to enhance lab activities by minimizing the manual preparation and increasing the time for discussion, intervention, and feedback. ICT-supported experiments are considered faster, more reliable, efficient, and accurate since they lessen the human error in measurements and unwanted input.

Tüysüz (2010) highlights the motivating impact of ICT on science lessons. For instance, the use of computer animations was found to increase students' engagement in the lesson. Additionally, using animations and enriched presentations were found to simplify hard and abstract scientific concepts, increasing students interest in science. On the other hand, Babateen (2011) points out that one of the most significant advantages of using ICT in science learning is that it facilitates the study of many scientific phenomena that cannot be done in the science laboratory due to their danger or cost.

In a study on the impact of ICT on learning in the United Kingdom (UK), teachers were asked to identify the key factors of ICT used in science education. The identified elements were using simulations and modelling software to investigate certain topics and using laptops for data logging and using online resources when up-to-date information is needed (Harrison et al. 2002). Another study that investigated the usefulness of CAI in science education found that students achieved higher scores when using CAI. CAI was found to simplify the understanding of different science concepts, such as equilibrium, by providing scientific visualisation software and innovative graphical interfaces (Park, Khan & Petrina 2009).  Animations in science education, such as videos presenting concepts that are hard to understand or imagine, can challenge students thinking and facilitate reflection on their conceptual understanding (Condie & Munro 2007). For example, animation could be used to demonstrate how water molecules act when the temperature increases and transforms ice to water and then to steam (Moore 2005).

Computer simulations, which are programs that allow the students to explore real-world phenomena using step-by-step methods, were also found to assist science education by allowing students to perform experiments that could be otherwise dangerous or expensive, such as an activated nuclear device, or to observe incidents that happen too fast or too slow, such as a bird's wings flapping or the lifecycle of a tree. Simulators were found to deepen students' understanding of scientific concepts and encourage decision-making roles by providing real-time results as well as allowing more time for data analysis and minimizing technical and mechanical work (Condie & Munro 2007). On a study on ICT affordances on science education, Webb (2005) claims that computer simulators have the power to impact conceptual changes even when they do not alter the current pedagogies or are not fully integrated in the curriculum.

On a study on model-based learning, Aegerter-Wilmsen et al. (2006) used a scientific simulation to present molecular life science and model laboratory data to biology students. The results showed a positive impact on students’ post-test outcomes. Similarly, Khan (2008) found that the use of computer scientific simulation had a positive impact on students’ chemistry learning. Computer simulations provide a cheaper and less time-consuming alternative to manual experiments (Sun, Lin & Yu 2008). Simulators remove the hassle of handling scientific gadgets and are able to present the theoretical background of an experiment, such as the representation of water evaporation along with the particle model (Mork 2005). Moreover, students who used simulators for graphing were found to perform better not only on the topic being studied, but also on other subjects such as graph interpretation and mathematics (Webb 2005).

Virtual reality is considered an innovative tool that can excel natural environments. Virtual laboratories use simulations in addition to other tools to create an environment that resembles real labs providing students with a unique level of interaction, personalized learning, and a wider scientific experience without the limits of time and space (Babateen 2011).

In the many parts of the world, including the Arab countries, virtual labs can compensate the lack of science laboratories, the high cost of lab material, and the danger of performing certain experiments (Babateen 2011). Teachers complain of the lack of time to perform experiments in crowded classrooms and therefore resort to demonstrations that deny the students the opportunity to construct their knowledge through hands-on activities. Thus, using virtual laboratory programs overcomes the obstacles and dangers faced by traditional laboratory and allows students to perform difficult experiments in a safe environment, more efficiently and effectively. Generally, many studies identified a positive influence of virtual or web-based laboratories on students’ performance. For example, a study on the use of virtual laboratories for chemistry found that students enjoyed using the software. However, when compared to traditional hands-on experiments, students were found to perform as well as students using the virtual laboratory (Tüysüz 2010).

On the direct impact of using ICT on students’ attainment in science, the ImpaCT2 report suggest that at Key Stage 3, students’ achievement in national exams can raise if ICT was frequently used in the classroom. In this key stage, ICT was used in about 33% of science lessons, which is the highest percentage compared to the use of ICT in English and mathematics. However, in Key Stage 2, high use of ICT was found to highly impact the results of students in English but not in science. There are many reasons that may have impacted the students' performance in science subject including a variety of methods used to integrate ICT in the lessons. In the schools were high use of ICT was recorded and students performed better, teachers associated the increase in attainment with the use of electronic sensors to plot and analyse graphs and tables which help them solve national tests questions involving interpreting graphs. Additionally, teachers linked students better understanding of the subject to the use of visual images and the faster access to information in general (Harrison et al. 2002).

In summary, ICT can provide a potential contribution to science education by delivering prompt feedback, directing students' attention to underlying abstract concepts, encouraging self and collaborative learning, improving students' motivation and engagement, and facilitating monitoring and assessment. Special programs such as virtual laboratories reduce the time needed to set up an experiment and facilitate the processes of measuring, tabulating, calculating, graphing and data logging (Osborne & Hennessy 2003). Students nowadays are digital natives and, consequently, it is required that science educators provide students with opportunities to use ICT not only as an input, but as an output of their understanding of science as well (du Plessis 2015).

### 2.4.2. ICT in Mathematics

As with science, there are many ICT tools evident in the literature that aid the evolution of mathematics education. For instance, the use of web-based technologies such as online assessment, was found to improve students' activities in mathematics by providing more opportunities for practice and self-evaluation. It also provides teachers with immediate feedback and grading, giving them extra time to interact closely with students. Additionally, web-based tools allow teachers to provide differentiated and personalized assessment (Nguyen, Hsieh & Allen 2006).

Condie and Munro (2007) described how using ICT helped students learn and understand the properties of quadrilaterals by linking concrete with abstract thinking. They also described how animations and simulations improved students' understanding in mathematics by providing graphical illustrations of concepts and procedures that may not be possible using traditional teaching resources. The use of ICT in mathematics activities provided the students with prompt feedback that motivated them, developed their critical-thinking skills, and encouraged collaborative learning. Additionally, the use of interactive programs facilitates differentiation and allows students to work at their own pace. For instance, less able students have the opportunity to practice more while more able students can progress to advanced tasks (Reimer & Moyer 2005).

The use of virtual mathematical manipulatives has also gained the interest of educators. Virtual manipulatives are dynamic imitations of physical manipulatives available on an application. Manipulatives in general are essential for concept development from a physical object to a representation in an abstract form. However, teachers usually face some difficulties in translating students' work with manipulatives to abstract concepts and symbols. What distinguishes virtual manipulatives over physical ones is the ability connect dynamic images with their abstract representations. For example, a 10-base virtual manipulative may show the visual representation of the block while presenting the value places in numbers. A study on computer-based manipulatives showed that they had a positive impact on students understanding of shapes. On the other hand, other studies on attribute block, pegboards, and geometric shapes showed no significant improvement on students' outcomes (Reimer & Moyer 2005).

Studies have indicated that in order to create a more effective learning environment, the teacher must consider all aspects, taking into account the overall process of teaching and learning. The role of the teacher in the process, including the language and ways in which he/she interacts with students, the use of non-digital tools such as pencils, and the time allotted for individual and group activities, all require special attention in planning the use ICT in teaching and learning mathematics (Condie & Munro 2007).

However, the studies show that ICT is not widely integrated in the mathematics pedagogies (Reimer & Moyer 2005). ICT was found to be used less in mathematics than in other subjects, where in some key stages, more than 70% of students never used ICT in mathematics (Condie & Munro 2007).

The ImpaCT2 report found that the percentage of ICT use in mathematics was the lowest compared to that in English and science. However, a positive link between the high use of ICT and students' scores was found, but was not considered statistically significant. As with science, there are many factors that influence the impact of ICT including teachers' practices and their teaching pedagogies. In schools where ICT was used and where students performed well in Key Stage 2, computers games were used to support low achievers learning, special software was used for data handling and graphs production, and interactive software was used for self-assessment and feedback. In Key Stage 3, teachers reported higher quality outcomes and improved commitment to course assignment (Harrison et al. 2002). In another study on European countries, a positive connection between the length of ICT use and students' achievement in PISA test was identified (Balanskat, Blamire & Kefala 2006).

## 2.5. Students Attitudes Towards ICT Use

How students think and perceive their learning is an essential input to teachers' pedagogies. Students can pin-point what they do not understand as well as how they prefer to learn and the means they like to use. Therefore, it is considered of great value to take into account students believes and attitudes towards ICT in order to increase their motivation and allow them to plan their own learning, and thus, enhance their learning experience (Webb 2005). In this regard, ICT was found to encourage students to be active learners and build their knowledge in an effective way (Ziden et al. 2011).

In general, the majority of teachers and students state that ICT has a positive impact on learning. In Europe, the majority of teachers agree that ICT has the power to motivate students, while another considerable number of teachers refute the notion that ICT has any positive impact on learning (Balanskat, Blamire & Kefala 2006).

In a study on university students, Kubiatko (2010) found that students have positive attitudes towards the use of ICT in science. A study on the effect of smart schooling on students' attitudes towards science revealed a positive link as well (Ong, Foo & Lee 2010). Other studies revealed that students found mathematics more enjoyable when using CBL. Students enjoyed practicing and trying new ideas on the computer, which increased students' motivation and confidence. According to the study, students' attitudes differ according to the pedagogy used in the classroom, such as assessment, resources, and themes. Web-based applications provide differentiated learning and assessment materials that allow students to have more control over their learning and therefore, increase their positive attitudes towards learning (Kahveci & Imamoglu 2007).

## 2.6. Approaches to Measure ICT Impact

Most of the literature comprises the convincing argument that ICT has a positive role in improving teaching as well as students' attainment and motivation. However, the evidence lacks consistency and conclusions are usually hesitant and uncertain due to the difficulties in stablishing the relationship between a specific aspect and its effect on achievement or motivation (Condie & Munro 2007). Understanding how educational technologies affect teaching and learning practices is essential for assessing their effectiveness and for developing improved tools. However, studying the direct link between the use of ICT and students' attainment is considered a complex task that needs considering all other factors that may affect students' outcomes. Additionally, the more the technology tool is embedded in the classroom practice the higher the impact. Thus, it is not wise to transfer results from one situation to another without understanding the context of ICT use. There is also a need to assess the teaching practices and learning conditions to understand under which circumstances ICT integration can improve learning. When studying ICT impact on learning, the use of ICT in a certain environment may produce unanticipated gains. This leads to researchers measuring the "wrong" output using the wrong instruments. Therefore, it is important to keep in mind that ICT can lead to a new way of thinking and new knowledge (Balanskat, Blamire & Kefala 2006).

Some studies follow an opinion-based approach based on students' and teachers' answers to surveys as well as interviews. Such studies are good to measure attitudes and perspectives but not the actual impact on attainment and achievement. Similarly, quantitative approaches lack the depth and ability to measure ICT impact on students' basic skills, motivation, confidence, and independent learning. As a result, in order to have a satisfactory evidence foundation, each qualitative approach should be supported by a quantitative method and vice-versa in order to measure the perceived learning experience and to understand the reasons and circumstances behind the positive perception.

When studying the impact of ICT in school subjects, it is essential to consider other variables that may influence the learning environment such as the school's strategy for ICT use and leadership style as well as parents' attitudes. Moreover, the characteristics of the students such as their interaction with technology inside and outside the schools, previous knowledge and motivation are all important factors to consider in order to effectively assess educational technology (Balanskat, Blamire & Kefala 2006). The way ICT is being integrated in the classroom as well as teachers' attitudes towards and proficiency of using ICT also play an important role in promoting students' learning. The way teachers plan their lesson and design their learning activities is what may lead to positive transformations in education (Webb 2005).

## 2.7. Related Studies

When studying ICT impact on education, researchers should choose what technology to study, on what group of learners, what outcome to investigate, and what approach to use. For example, some studies focus on the effect of specific technology on students' achievement, while others study the impact of that technology on students' motivation and engagement. Other studies investigate the impact on different ICT tools on special group of learners, such as those with special needs (Condie & Munro 2007).

Quantitative studies usually investigate students' performance on a specific subject or subjects by analysing students results in test after ICT implementation. A study on primary students in Malaysia found that students' learning outcomes improved after using ICT in form of visual presentations in science for a ten-weeks period of time (Ziden et al. 2011). Similarly, a study on elementary students showed that students who used web-based laboratory performed better than students who worked in a traditional laboratory (Sun, Lin & Yu 2008). Additionally, an OECD report linked the length of time students spend on an educational program to their improved score in PISA mathematics (Balanskat, Blamire & Kefala 2006).

A comprehensive study on ICT use in UK schools revealed that, when using ICT, students performed better in English and science but not in mathematics (Harrison et al. 2002). Similarly, a wide-ranged study showed that ICT investment in schools pays off the most on English subject, less on science, and not in mathematics (Machin, McNally & Silva 2006). Likewise, Cox et al. (2003) performed an extensive literature review regarding ICT and attainment and found a positive relation between them in most of the curriculum core subjects, namely English, Math and Science where there was a greater focus on investment on ICT resources. The impact was found to be stronger when ICT was used to support language acquisition and specific concepts in Math and Science. However, many studies signify a positive link between students' exposure to technology and their performance in mathematics and science (Higgins et al. 2005; Underwood 2006; Delen & Bulut 2011).

Qualitative studies, on the other hand, seek to study the impact of ICT on learning outcomes according to teachers' and students' perspective. In many studies, teachers believe that ICT has a great impact on students learning, improves students' skills and performance, and benefits advanced students the most but serves weak ones as well (Tikam 2013).

Other studies focus on secondary impacts of ICT on education. A study on grade 3 students showed that the use of virtual manipulatives increased students' motivation and engagement and were found easier to use than physical manipulatives (Reimer & Moyer 2005). The use of whiteboards was also found to have a positive motivational impact on students (Higgins et al. 2005). Similarly, studies show that ICT improves communication and behaviour (Comber et al. 2002).

Appendix A includes studies that point to the impact of integrating ICT in teaching and learning, which are discussed and categorized according to the target of the influence, namely the impact on learners, teachers, and pedagogy.

## 2.8. Summary

This chapter described the basic theories underlying this research. Understanding how students learn and how they perceive their learning is essential for a sound perception of the research standpoint. Additionally, considering the aspects that comprise an instructional setting is central to the study of any CAI tool and its use in the classroom. The thorough understanding of cognitive, behavioural and constructivism theories, accompanied with the comprehension of the factors that affect students' attitudes and learning outcomes are essential to the construction of the research instruments.

The role of ICT and its contribution to education in general and to specific subjects in particular have been also outlined in this chapter. Moreover, studies reporting the impact that ICT has on different school subjects have been presented. These studies show how different school subjects benefit from ICT to different extents. This study aims to investigate whether these differences are evident between mathematics and science in grade three. The researcher believes that even though differences may be found in students' attitudes and achievement in both subjects, it is very important to understand what are the factors that caused one subject to benefit more than the other.

# 3. Chapter Three: Methodology

Identifying the research design is a crucial step to guarantee the validity of results (Ary et al. 2013). This chapter describes the research methodology of the study by providing details on the procedures, design, participants, context, and ethical considerations. It also provides detailed description of research instruments as well as the rationale behind choosing them, their validation and reliability, and a suggested analysis plan.

## 3.1. Research Approach and Design

The objective of this research is to investigate the impact of ICT use in students' attitudes and achievement in mathematics and science. This study mainly adopts a post-positive knowledge claim supported by an interpretive paradigm. Post-positivism assumes that knowledge is conjectural. Thus, the scientific research usually starts with a theory and a claim, and then gathers data that eithers confirms or refutes the theory. On the other hand, the interpretive paradigm adopts the notion that there is a need to interpret and discover the underlying causes of a certain phenomenon (Creswell 2013). Therefore, this study follows a mixed methods approach by employing the data collection methods associated with both the quantitative and qualitative forms of data. Mixed methods approach allows the researcher to expand the understanding from one method to another, and confirm findings (Creswell 2013). The method used in this study is a concurrent embedded approach where a "quasi-experimental" quantitative approach occurred at the same time of an "observation" qualitative approach. However, in this study, more weight is given to the experimental approach.

A questionnaire was used to measure students' attitudes after the use of ICT (treatment group) in the computer lab as well as a pre- and post- test to measure the achievement in mathematics and science without using ICT (control group) and with the use of ICT (treatment group). Students' attitudes and achievement are the dependant variables in this study while the use of ICT in the computer lab is the independent variable. Creswell (2013) maintain that quantitative experiments are essential tools to examine the relationship between variables and answer the research hypothesis. The validity of collected data and used instruments lead to meaningful interpretations of data. The main objective of an experimental design is to test the impact of the intervention (i.e. using ICT) on an outcome, while trying to control and exclude all other factors that may impact that outcome. However, when using quantitative methods, knowledge produced might be abstract or general to be applied to specific situations. Additionally, categories used in quantitative data collection may not reflect the current population understandings. Such constraints of quantitative methods call for the need of qualitative methods to provide a better understanding of the context being studied as well as support the quantitative data analysis by providing a different perspective (Johnson & Christensen 2010). To support the quantitative method with qualitative data, a structured/non-participant observation approach was used to collect data on students' behaviour in the computer lab as a supplementary procedure. Even though the structured observation approach is criticized as being subjective, observing certain behaviours is important to support the research objectives and hypotheses (Bell 2005).

## 3.2. Sampling and Procedures

A total of 41 students from two grade-three classes from a private school participated in this research. No randomized techniques were used as students were already assigned to their classes by the school. One class was considered as the experimental group (EG). A special online application in the computer lab was used to deliver instructions to the students in the experimental group. The other class was considered as the control group (CG) where the teacher in the classroom delivered the instructions to the lesson. The experimental group had a total of 21 students, of which 14 were male and 7 were female. The control group had a total of 20 students, of which 12 were male and 8 were female. The majority of the students in both groups were Emiratis (17 in EG and 16 in CG). All the students spoke Arabic as a first language. Moreover, all the students studied ICT as a separate subject as part of the school curriculum and therefore, they had acquired the skills needed to use the software of concern. Both groups had a close average score for previous terms in both mathematics (EG: 88.2%, CG: 89.45%) and science (EG: 84.3%, CG: 84.53%). Table 1 summarizes the characteristics of the study sample.

*Table 1: The Study Sample*

| | Experimental | Control |
|---|---|---|
| Method of Instruction | Using ICT | Without using ICT |
| Number of Students | 21 | 20 |
| Number of Female Students | 7 | 8 |
| Number of Male Students | 14 | 12 |
| Number of Emirati Students | 17 | 16 |

Two teachers were involved in this research; a mathematics teacher and a science teacher. Both teachers taught the control and experimental groups from the beginning of the school academic year. Both teachers had five years' experience in the school but the science teacher had more years of experience in total. Additionally, they are both regular computer lab users and both stated that they feel confident using the computer lab and the specified software. All the classes and computer lab visits took place during the regularly scheduled mathematics and science classes.

This study used an unrelated design where different participants are assigned for each condition in order to ensure that each student is subjected to only one condition (Greene & d'Oliveira 2005). This research follows a time series quasi-experimental two-group research design. Participants assignment in the quasi-experiments lack the random element of true experimental design but maintains all its other advantages (Cook 1979). A time series quasi-experimental design allows the researcher to determine the changes in variables before and after the intervention (Creswell 2013).

*At the beginning of the study, both groups were given two sets of pre-test questions to identify their prior knowledge of the subject (if any) in both mathematics and science. Then, students in the control group took lessons in the classroom and the teacher was responsible of delivering the material to students without the use of ICT (see* Appendix B*). On the other hand, students from the experimental group took their lessons in the computer lab using the online software (see Figure 4, Figure 5, and Figure 6 in Section* 3.3*). Two sets of post-tests questions (the same as the pre-test questions) were given to both groups after the experiment for both subjects (see* Appendix C*). An attitudes questionnaire was administered twice to the experimental group only; after the science lessons and after the mathematics lessons. The time of instruction was unified for all the lessons in the classroom as well as in the computer lab in order to remove the time variable. Pre- and post-tests as well as questionnaires were administered outside the time frame of the lesson, which was 55 minutes each excluding the time to arrive to the computer lab for the experimental group. All the pre-tests as well as the post-test for the control group were administered as paper-and-pencil. The post-test for the* *experimental group as well as the attitudes questionnaires were administered on the computer in the lab.*

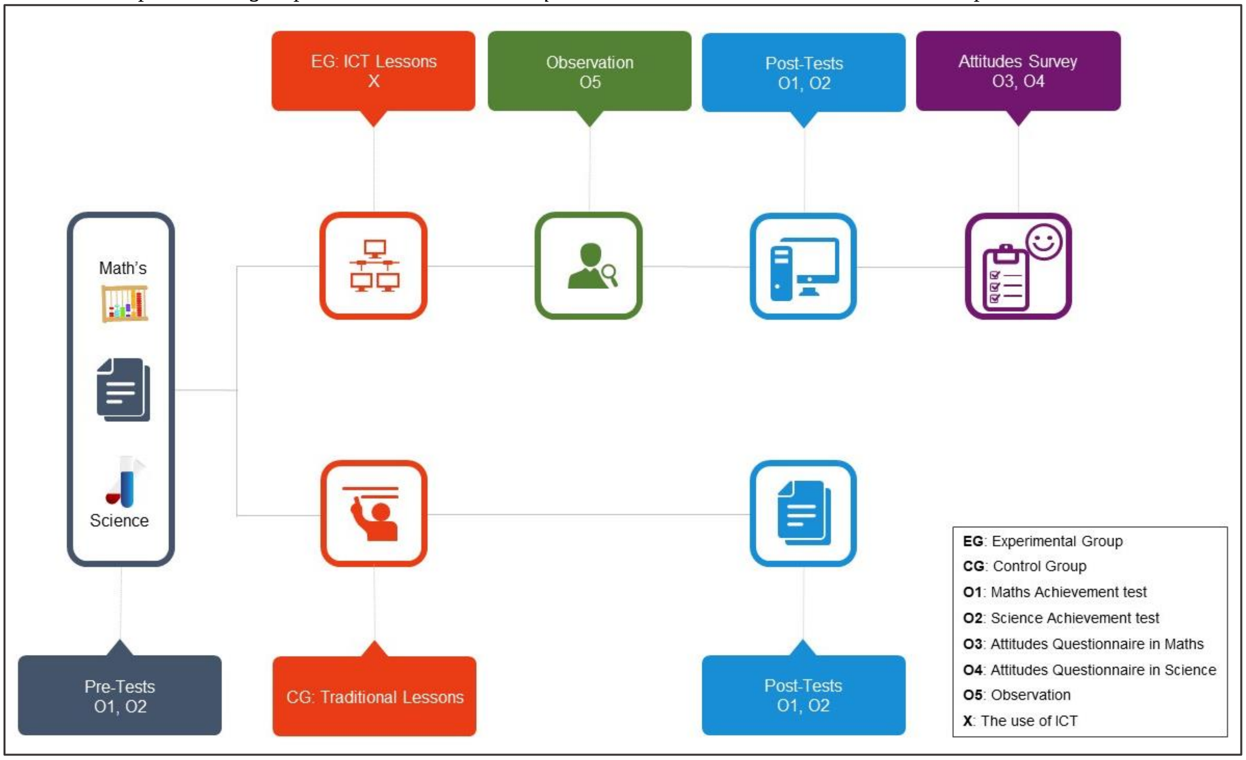


Figure 2 shows the research design and procedure for this study.

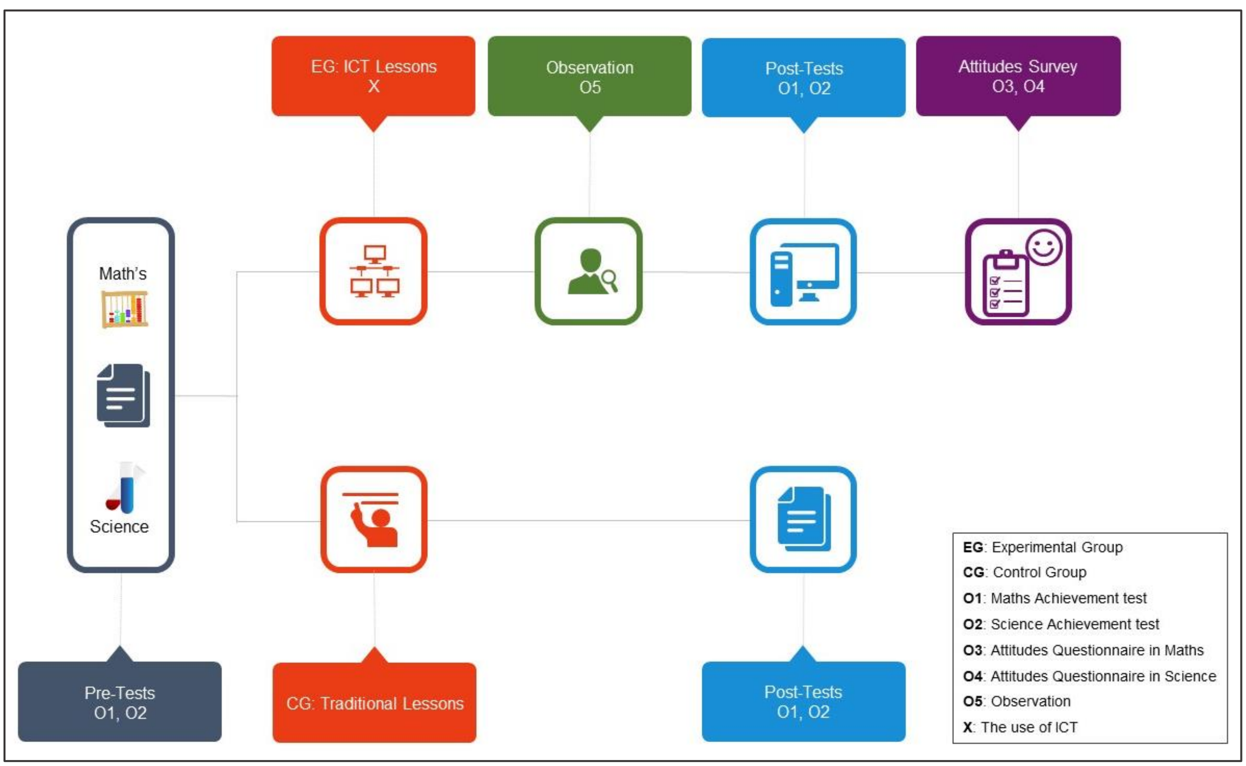


*Figure 2: Research Procedure and Design*

## 3.3. Instrumentation

The instrumentation process involves selecting and designing the research instruments and designing the procedures and settings of administering the instruments (Fraenkel & Wallen 2003). If the research instruments are well planned and designed, a base for the collection, analysis and demonstration of data can be guaranteed (Creswell 2013).

Different types of instruments have been employed in this study in order to collect the needed data. The first tool is the pre- and post- test that was used to measure students' achievement before and after the intervention. The second tool is the post-questionnaire to measure students' attitudes towards the use of ICT. The third tool is the classroom observation to note students' behaviour as well as any evident trends. The collected data will be studied, discussed and assessed with the purpose of answering the research questions and test the hypotheses.

### 3.3.1. Students Questionnaire

Attitude questionnaires are a special form of questionnaires in which they are developed in order to ensure that responses can be summed to produce a single score representing one attitude. Questionnaires are often chosen over interviews and diaries because they provide confidentiality, allow the participant time to answer, can be given to many participants at once, provide standardization of measurement situations and facilitates data interpretation. However, questionnaires lack the flexibility that other tools can provide (AECT 2011).

A new questionnaire was developed specially for this research. Even though some suggest that using existing questionnaire or customising them provide the research a validated and reliable tool (Creswell 2013), developing a specific questionnaire that target the research objectives can significantly lessen measurement error. However, in this case, the researcher should pay a great attention to establish the instrument validity and reliability (Estabrook & Wallin 2004).

A widely used approach in developing an attitude instrument is using the Agreement or Likert scale. This measurement technique is considered easy to score and analyse data obtained. It involves the use of statements regarding the attitude that are either positive or negative (Creswell 2013). Students in this research were asked to answer questionnaire items by choosing their perceived attitude "strength" towards the statement using a five-point scale (strongly agree, agree, neutral, disagree, strongly disagree).

The survey questions were first presented to a group of primary teachers who added their comments on the language of the questions as well as the content. The final version of the questionnaire contained 8 items (7 positive and one negative), referring to enjoyment and motivation, clarity of procedures and organization of classroom, and ICT support for learning. The wording of the questionnaire items was simplified to suit students' level. Two versions of the questionnaire were created; one to be used after the mathematics classes in the lab and the other to be used after the science classes. Both versions were exactly the same except for the words "mathematics" and "science". This instrument was used with the treatment group to measure students' attitudes towards the use of ICT in mathematics and science. The questionnaire was delivered to students through a network software that requires the students to login with their school IDs in order to access it. Answers are then stores on the main computer device in the computer lab in form of an Excel sheet.

#### 3.3.1.1. Validity and Reliability of Students' Questionnaire

When building a new questionnaire, it is important to establish its validity and reliability. Content validity measures were used to examine whether the questionnaire fully measures the subject of interest, which is in this case the use of ICT in mathematics and science (Bolarinwa 2015). First, the researcher ensured that the questionnaire includes different domain of the attitude to study based according to the related literature. Second, the instrument was reviewed by a group of other colleagues to assess clarity, readability and comprehensiveness. After receiving participants' data, the information was scanned to ensure that no students answered using the same Likert score for all the questions or used one number to answer more than six items. Data triangulation by the additional collection of data through observation will ensure internal validity of the questionnaire.

In order to assess the construct validity and internal consistency of the questionnaire, exploratory factor analysis (EFA) was used to reduce the number of variables (the eight questions) to a few underlying dimensions. EFA examines the associations between variables, based on the correlations between them, to see if there are underlying factors. EFA allows to find out whether the variables could be grouped into smaller number of composite variables to use to convey as much of the information in the observed/measured variables as possible (Leech, Barrett & Morgan 2005). Appendix D presents the validity and reliability analysis of the attitudes questionnaire.

### 3.3.2. Pre- and Post- Tests

Pre- and post- tests were designed to measure students' achievement score before and after the intervention. The questions in the post-test were chosen from the questions bank accompanying the book, available both in the teacher's edition and in the interactive online application. The reason the post-test was designed first is to make sure all the chosen questions are available online for the treatment group to use in the computer lab. Both mathematics and science tests contained ten multiple choice items ranging in difficulty and were marked as either correct or incorrect. All the items are directly related to the objectives of the lessons in the study. The pre-tests contained the same items as in the post-tests but with different numbers and/or different rearrangement of options. A time limit was set to students in both groups to ensure a standardized testing environment (Ediger 2003). Additionally, in order for the achievement to be a useful quantifying tool, there should be a direct link between the test content and the lesson the students have been exposed to (Ary et al. 2013).

The pre-tests were administered to both the control group and treatment group to measure students' pro-existing knowledge on the subject prior to the classroom or computer lab experience. The post-tests were administered after the control group took the lessons in the classroom and the experimental group took the lessons in the computer lab. Figure 3 demonstrates an example of a mathematics post-test item. Full version of achievement tests for mathematics and science are included in Appendix C.1 and Appendix C.2 respectively.

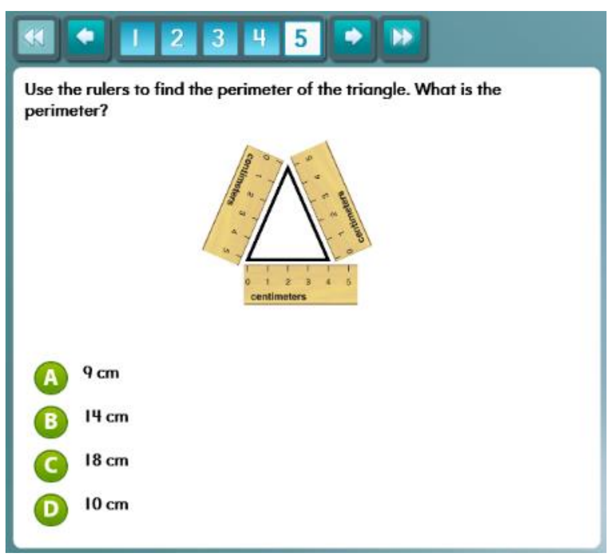


*Figure 3: Mathematics Post-Test Item*

#### 3.3.2.1. Validity and Reliability of Pre- and Post- tests

When administering achievement tests to measure students' knowledge and abilities in a particular domain, the main goal is to acquire valid scores for the students (Wise 2015). The validity of achievement tests represents their ability to measure students' achievements in the subject of concern.

To ensure internal validity of the pre- and post- tests of this study, the researcher ensured all procedures are clear and are followed as planned. The researcher as well as the teachers ensured standardized testing environment and prevented students from talking with each other during the test. The study was conducted in a relatively short period and therefore there are no threats of participants changing in characteristics. External threats of validity were minimized by changing some details and numbers in the post-tests but maintaining the same format. However, the effect of a pre-test to a following test has been empirically proven (Willson & Putnam 1982).

To ensure content validity of the tests, a pilot test was conducted to a group of grade-three students from the school. Piloting the achievement test helps improve questions and eliminate unnecessary ones and ensures that students' scores range from low to high. Additionally, it allowed the researcher to estimate the time that should be allotted for each test. However, it is important to note that validity is not a variable that can be measured. It is therefore something that can be inferred and judged as being acceptable, marginal, or unacceptable. When an instrument is being judged as valid, it is to say that it is an effective tool to measure as well as predict and generalize (Messick 1979).

### 3.3.3. Classroom Observation

A structured non-participant observation approach was used to collect data on students' behaviour in the computer lab as a supplementary procedure. The need to observe students in the natural settings comes from two main reasons. First, students' affective and cognitive components of attitude may not always match the behavioural component. For example, the students may "believe" that the use of computers is easy and "feel" that the use of them is fun, but in reality, he/she might be confused on what to do or may act irritated and angry (Johnson & Christensen 2010; Mensah, Okyere & Kuranchie 2013). Therefore, there is a need to observe the behavioural component of attitude within a natural setting. Second, being involved in the study and observe procedures closely allow the researcher to form a better picture of the study and note any out of the ordinary events (Fraenkel & Wallen 2012).

The researcher observed the four lessons conducted in the computer lab. A table with the main expected behaviours was designed to be used to note down observed behaviours. As a former elementary computer teacher, the researcher has a background of students' behaviour in the computer class in the ICT lessons as well as in other subjects. Based on that as well as on the related literature, the researcher observed and noted down any behaviour that represented the attitudes' questionnaire main categories as well as any other actions that were perceived to influence the study. Teachers' introduction to the lesson in the computer lab as well as their delivery of instructions on what to do with the computer were recorded. Additionally, students' interactions among each other as well as among the teacher, their engagement in the lesson and their questions about the material presented were noted down.

### 3.4. Data Analysis

Data collected from the questionnaire was used to determine students' attitudes towards the use of ICT in mathematics and science using mean and standard deviations. Additionally, paired samples t tests were used to measure whether there is a significant difference in students' attitudes between mathematics and science.

Pre-tests for both groups (experimental and control) as well as the post-tests for the control group were corrected manually by the teachers and researcher. Scores were manually entered to an Excel sheet. Post-tests score for the treatment group were automatically generalized from the online software and exported to the same Excel sheet to match each score from the pre-test with its corresponding post-test. Data collected from the pre- and post- tests was used to test whether students performed differently when using ICT and without using two-way Mixed ANOVA. Additionally, a paired-samples t test will be used to detect significant differences between mean progress score of mathematics and science.

Data from the classroom observation will be collected and categorized according to the type of behaviour for both students and teachers. Additionally, the frequency of some repeated behaviours will be recorded.

## 3.5. Context and Scope of the Study

The study was conducted in a private school in the UAE. The school follows an American curriculum. The school is accredited by New England Association of Schools and Colleges (NEASC) and has received a "Good" overall rating from Dubai School Inspection Bureau (DSIB) in the year of the study. The majority of teachers are Arabs and the majority of students are Emiratis. The school provides education to about 1,700 students from kindergarten to grade twelve. The language of instruction is English except for Arabic, Islamic and social studies.

The classrooms in the school are only equipped with overhead projectors that can be connected to the teachers' laptops. Students do not have tablets or laptops. Therefore, teachers use the computer labs to allow students to use online websites or any specialized software. The school have eight computer labs situated in each section of the school. Each computer lab has 30 computers for students that are connected to the teacher's main computer. The lab also contains an overhead projector connected to the main computer. Students use the computer lab for all ICT classes as well as for other subjects such as science, mathematics, biology, English, and Arabic.

The study was conducted during the third term of the academic year of 2016/2017. Students at this time of the year are usually confident with the use of computers and are well aware of the procedures inside the computer lab. Each lesson, which is 55 minutes, took place during the regular mathematics and science classes. The experimental group as well as the control group were taught by the same teachers (a teacher for mathematics and a teacher for science) to ensure similar experiences, teaching quality, and resources (Creswell 2013).

Mathematics was taught using Houghton Mifflin Harcourt's Go Math! (2015), while science was taught using Houghton Mifflin Harcourt's Science Fusion (2012). The content of the mathematics classes in this study included the "Perimeter" chapter. While the content of the science classes consisted of the "Earth and Its Moon" chapter.

In the mathematics classes for the control group, the teacher used traditional pedagogies to explain to students how to find the perimeter. The teacher used physical manipulatives of shapes and used the board to draw shapes and rulers to calculate their perimeters with the students. Students then solved the book exercises to practice (*See Appendix B and Appendix B.1*). For the experimental group, the teacher took the students to the computer lab. Students then logged in using their personal accounts and engaged in an interactive explanation of the lesson. Figure 4 shows a screenshot of the “Animated Math Models”, while Figure 5 shows a screenshot of the “Interactive Personal Math Trainer” which were used to explain the perimeter lesson to the students and engage them in interactive tasks.

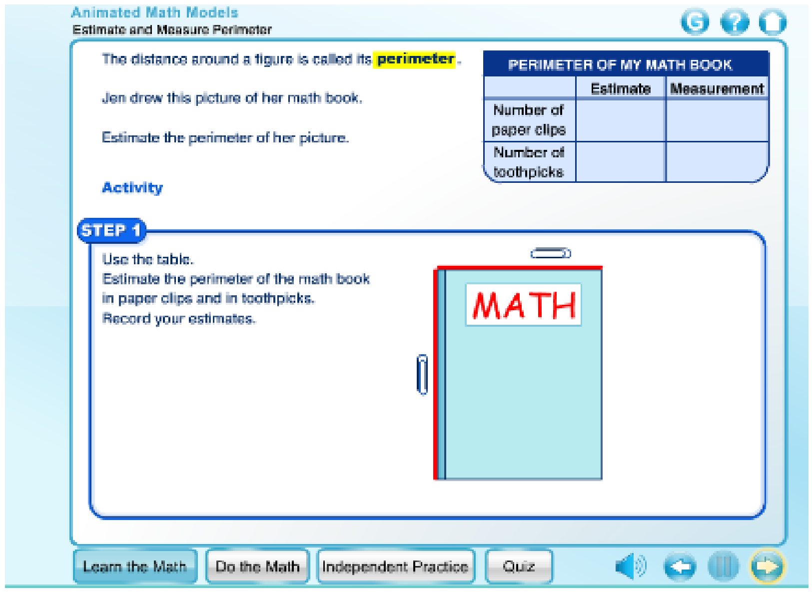


*Figure 4: Animated Math Models*

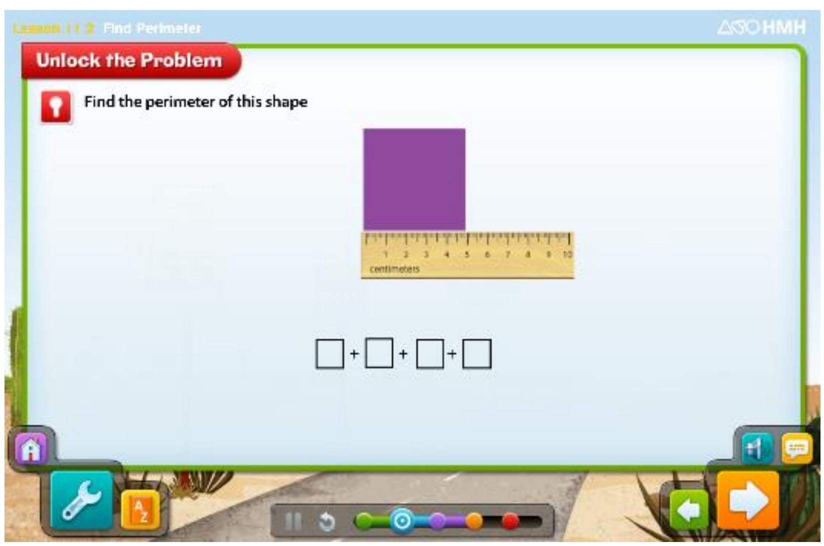


*Figure 5: Interactive Student Edition (Personal Math Trainer)*

In the science classes for the control group, the teacher explained the lesson by guiding the students through a diagram of the moon phases in their books and by modelling the phases using manipulatives. Students then solved some exercises from the book (*See Appendix B.2*). For the experimental group, the teacher took the students to the computer lab and gave them a brief on what to do and expect. Students then logged in and engaged in an interactive virtual explanation of the lessons. Figure 6 shows a screenshot from the "Virtual Lab" that allows the students to experiment and rotate the moon to see how it causes the moon phases.

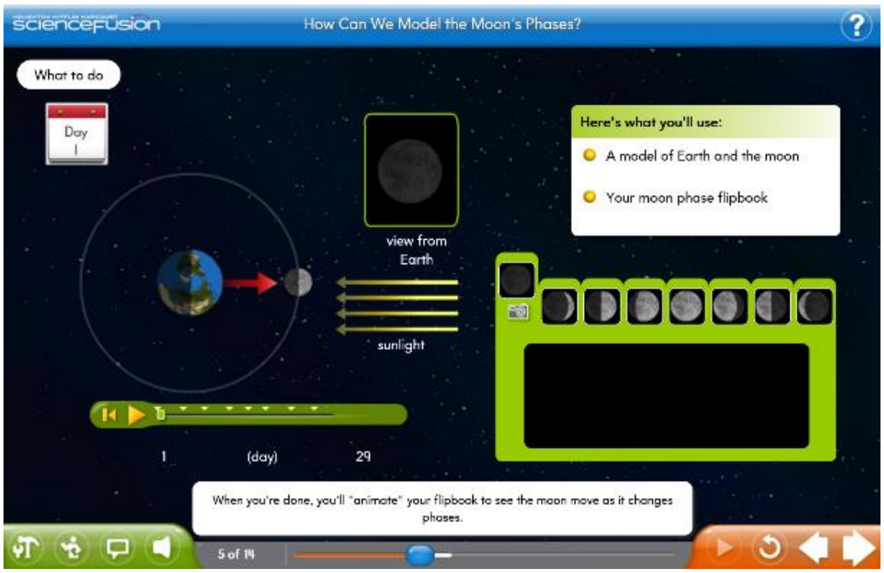


*Figure 6: Virtual Lab for the Moon Phases*

In both mathematics and science classes, students logged in to the ThinkCentral website (thinkcentral.com). Each student has his/her own username that can be used in and outside the school. The teacher can assign homework and quizzes to the students and follow up their progress. After the students log in, a screen with "Things to Do" appears to the students. The teacher guides the students as to which exercise or quiz to choose. ThinkCentral is an online software that accompanies the students' books. Teachers can choose the "Print Path" by using the book, the "Digital Path" by using ThinkCentral online resources and interactive lessons, or mix between both.

Pre- and Post- tests for both subjects were generated from the teacher's login account to the website. Questions were carefully selected to ensure accurate measurement of students' achievement scores. Questions ranged from relatively easy to relatively hard to ensure differentiation.

### 3.6. ICT Tool Design

Evaluating the effectiveness of digital tools in education is essential. Students should be able to benefit from the software as well as enjoy using it. Otherwise, such implementation would waste precious learning time. Developers of digital learning materials work hard to meet these challenges by designing learning environments that support teaching, learning and assessment, and enable students to carry out complex tasks, provide feedback, and deliver assessment (Mork 2005).

Both interactive software (CAI) used in mathematics and science in this study included a wide range of animations accompanied by audio and on-screen text prompts. The interface of the tool provided many options to the students such as the ability to repeat the instruction or to navigate back and forth between the questions. Additionally, they both gave many chances to students to re-answer the questions and provided prompt feedback when the student advanced to the next step. However, no personalization nor differentiation was evident in the tool.

In one of the mathematics lessons, the “Personal Math Trainer” started by presenting the students with a problem, followed by a set of questions that helps the students draw conclusions. On the other lesson, “Animated Math Models” started by revising the meaning of perimeter and how to calculate it, followed by “dill and practice” questions. The images in both lessons were mainly of plain geometric shapes with a visual representation on how to find the perimeter. Few of the shapes were transformed to real life examples, such as picture frames and farm fences.

On the other hand, the science lesson resembled more an astronomy lab where students had to “view” the moon from different positions and record their observations. Students in science had more chances to be active learners by having the opportunity to experiment, observe, and record the Moon Phases.

### 3.7. Ethical Considerations

The researcher in this study will be responsible of administering the pre- and post-tests and the students’ questionnaire as well as observing the class during the treatment sessions. To avoid the researcher bias during observation, a pre-defined set of aspects were used to collect data as well as allowing the flexibility to add additional observed aspects (if any). Additionally, the observation data will be used to support the quantitative data analysis and not the opposite.

Moreover, the researcher will ensure that teachers do not influence students answers either on the achievement tests nor the attitudes questionnaire (Creswell 2013).

Other ethical concerns were taken into consideration. First, a permission letter was sent to and signed by the principal of the school with the aim of authorising the carry out of the research study. Second, all the collected data, such as students' achievement scores, was kept confidentially along with the students' and teachers' identities. Moreover, teachers were informed of the research objectives and processes and were aware of the observation process. Finally, parents were sent a consent form informing them of the study aims and procedures. Such ethical matters are essential since revealing participants' identities or involving them in a research without their permission is considered a violation of their right of privacy and anonymousness (Creswell 2013).

# 4. Chapter Four: Results, Analysis and Discussion

This study aims to identify the effects of ICT use on students' attitudes and achievement in mathematics and science. This chapter presents the findings and analysis of the quantitative and qualitative instruments data in order to answer the research questions and test the hypotheses.

To answer the research questions, quantitative data was first coded and analysed using descriptive and inferential data analysis. Statistical tests provide a tool for testing research predictions and analyse the results of psychological study. Experiments are designed to test whether predictions coincide with psychological theories and previous studies (Greene & d'Oliveira 2005). After determining the outputs of quantitative data, qualitative data was analysed and compared to the quantitative results. The quantitative data was analysed using the Statistical Package for the Social Sciences (SPSS v.22). Qualitative data was then examined and searched for patterns to interpret the quantitative data (Bloomberg & Volpe 2012).

## 4.1. Quantitative Results

In this section, results obtained from the SPSS are presented and illustrated with tables followed by a discussion of the findings. Reliability and validity analysis of the questionnaire is included in Appendix D. The research hypotheses are tested against null hypotheses, which assume that the results found in the study are due to a random variability in the students' results rather than the predictions that are being tested (Greene & d'Oliveira 2005).

### 4.1.1. Descriptive analysis of Attitudes Questionnaire

The researcher used the means and standard deviations to summarize and describe responses data, as shown in Table 2.

The results indicate that the items scores of attitudes in mathematics was generally 'Medium' with a mean score of 2.94 and a standard deviation of 0.487. The items scores of attitudes in science was generally 'Medium' as well with a mean value of 3.23 and a standard deviation of 0.477. As can be seen from the table, the means of attitudes in mathematics ranged from 2.48 to 3.62, and from 2.33 to 3.81 in science. Item 3 "*The activities in the Maths/Science lesson on the computer are fun and interesting*" ranked first in both mathematics and science with a mean of 3.62 and 3.81

respectively. The second highest ranked item was item 1 *"I enjoy the Maths/Science class when it is the computer lab"* with a mean of 3.29 in mathematics and 3.76 in science. On the other hand, item 7 "*I know what I am expected to do with the computer in the Maths/Science class.*" ranked last with a mean of 2.48 for mathematics compared with 2.33 for science.

*Table 2: Univariate Statistics for Attitudes Towards the Use of ICT*

| | Mathematics | | | Science | | |
|---|---|---|---|---|---|---|
| **Attitudes** | **Mean** | **SD** | **Attitude** | **Mean** | **SD** | **Attitude** |
| 1. I enjoy the Maths/Science class when it is the computer lab. | 3.29 | 1.347 | Medium | 3.76 | 1.546 | High |
| 2. The use of Computers in the Maths/Science class does (not) make me nervous. | 2.95 | 1.341 | Medium | 3.48 | 1.209 | Medium |
| 3. The activities in the Maths/Science lesson on the computer are fun and interesting. | 3.62 | 0.740 | High | 3.81 | 1.365 | High |
| 4. I can achieve better marks when learning Maths/Science on the computer. | 3.00 | 1.179 | Medium | 3.71 | 1.271 | High |
| 5. The use of computers makes me understand more the Maths/Science Subject. | 2.76 | 1.135 | Medium | 3.10 | 1.261 | Medium |
| 6. It is easier to learn from using computer than from the Maths/Science book. | 2.52 | 0.980 | Medium | 2.48 | 1.123 | Medium |
| 7. I know what I am expected to do with the computer in the Maths/Science class. | 2.48 | 0.978 | Medium | 2.33 | 0.730 | Medium |
| 8. The Maths/Science class in the computer lab is well organized. | 2.90 | 0.889 | Medium | 3.14 | 1.062 | Medium |
| **Overall Mean and standard deviation** | 2.94 | 0.487 | Medium | 3.23 | 0.477 | Medium |

Items 1 and 3 represent students' enjoyment when using the computer, which aligns with the results of many previous studies stating that the use of ICT has a positive impact on students' attitudes and motivation (Mork 2005; Kahveci & Imamoglu 2007; Park, Khan, & Petrina 2009; Tüysüz 2010). On the other hand, the lowest ranked item in both mathematics and science (item 7) represents students' understanding of procedures and clarity of instruction, which might be affected by external factors such as language barriers, lack of detailed planning, and teacher's experience and confidence (Moore 2005).

By examining the bar charts, Figure 7 and Figure 8, the condensed distributions of third-grade students' responses as Disagree/Agree scores can be seen for both subjects, mathematics and science. For mathematics, it can be seen that items 1 and 3 have higher positive attitudes than other items as they have, on average, 57% and 62% positive scores, respectively. For science, the highest overall percentage of positive scores was achieved for items 1 and 4, with 76% and 67% positive scores, respectively.

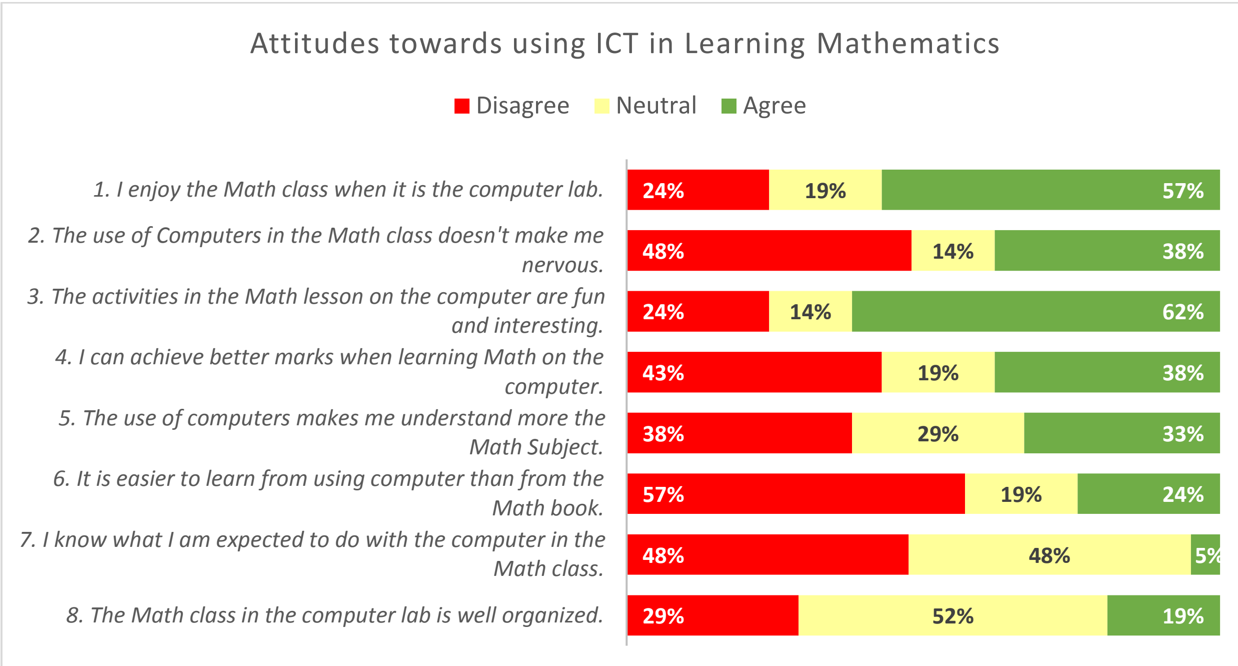


*Figure 7: Bar Chart of Attitudes Towards Using ICT in Learning Mathematics*

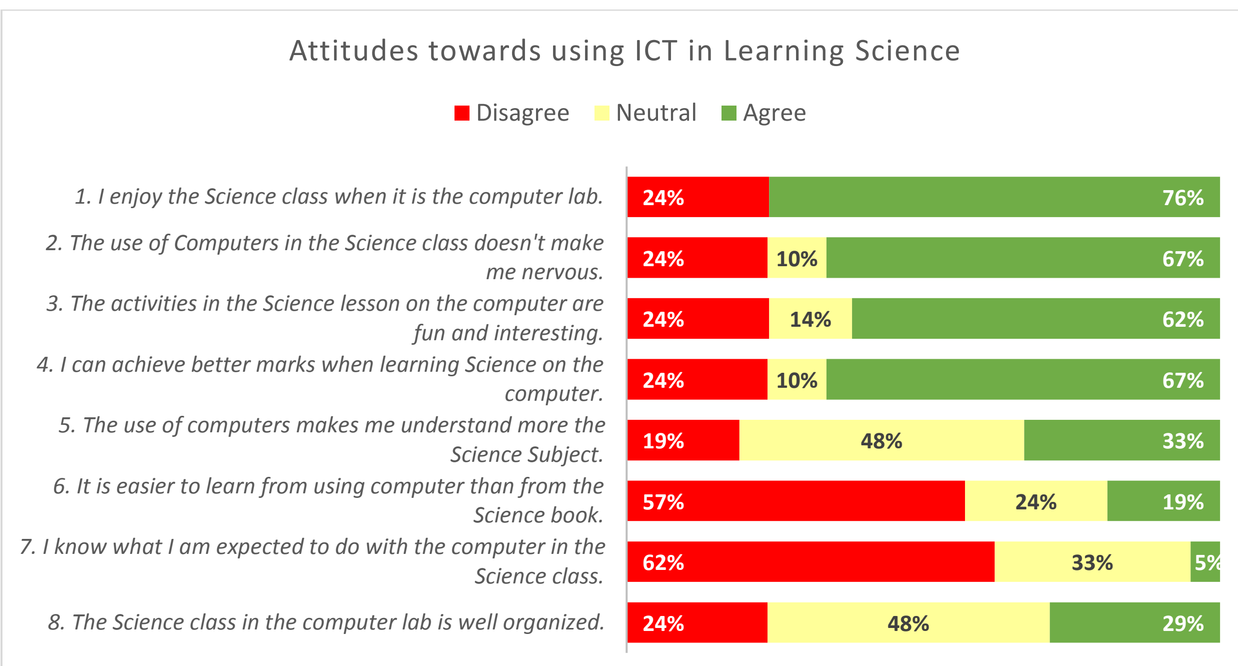


*Figure 8: Bar Chart of Attitudes Towards Using ICT in Learning Science*

The impact of ICT on students' attitudes is highly dependent on how it is used (Balanskat, Blamire & Kefala 2006). First, teachers' attitudes towards the use of ICT, their confidence in using it, and their pedagogy, all affect how students perceive the lesson (Ziden et al. 2011). Second, students' confusion or lack of understanding of procedures may result in students feeling bored or nervous and not be able to enjoy the class (Moore 2005).

### 4.1.2. Testing the Research Hypotheses

As mentioned earlier, the current study aims at answering five key questions, which can be done by testing five hypotheses.

#### 4.1.2.1. $H_{A1}$: There is a Significant Relationship at Level ($\alpha \leq 0.05$) in Students' Use of ICT and Their Attitudes Towards it

Due to the fact that some of the composite factors were not satisfactorily reliable (*see Appendix D*), individual items were used in running the one-tail one-sample t-tests to test this hypothesis, as shown in Table 3. One sample t test can be used to determine if the mean of a sample is different from a particular value (Greene & d'Oliveira 2005). In this study, the researcher determines if the mean score of third-grade students' attitudes for both subjects is greater than 2; 2 reflects "Disagree" score on the measurement scale of attitudes, and higher scores indicate positive attitudes.

*Table 3: One-Tail One-Sample T Test for Positive Attitudes Towards ICT Use Using Individual Questionnaire Items*

| | **Test Value = 2 (N = 21)** | | | | | |
|---|---|---|---|---|---|---|
| | | | | | **95% CI of the Difference** | |
| **Attitudes** | | | | | **Lower** | **Upper** |
| 1. I enjoy the Maths class when it is the computer lab. | 4.374 | 20 | 0.000 | 1.286 | 0.67 | 1.90 |
| 2. The use of Computers in the Maths class doesn't make me nervous. | 2.911 | 20 | 0.009 | 0.952 | 0.27 | 1.63 |
| 3. The activities in the Maths lesson on the computer are fun and interesting. | 5.063 | 20 | 0.000 | 1.619 | 0.95 | 2.29 |
| 4. I can achieve better marks when learning Maths on the computer. | 3.090 | 20 | 0.006 | 1.000 | 0.32 | 1.68 |
| 5. The use of computers makes me understand more the Maths Subject. | 2.769 | 20 | 0.012 | 0.762 | 0.19 | 1.34 |
| 6. It is easier to learn from using computer than from the Maths book. | 1.596 | 20 | 0.126 | 0.524 | -0.16 | 1.21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7. I know what I am expected to do with the computer in the Maths class. | 2.911 | 20 | 0.009 | 0.476 | 0.13 | 0.82 |
| 8. The Maths class in the computer lab is well organized. | 3.970 | 20 | 0.001 | 0.905 | 0.43 | 1.38 |
| 1. I enjoy the Science class when it is the computer lab. | 5.222 | 20 | 0.000 | 1.762 | 1.06 | 2.47 |
| 2. The use of Computers in the Science class doesn't make me nervous. | 5.595 | 20 | 0.000 | 1.476 | 0.93 | 2.03 |
| 3. The activities in the Science lesson on the computer are fun and interesting. | 6.077 | 20 | 0.000 | 1.810 | 1.19 | 2.43 |
| 4. I can achieve better marks when learning Science on the computer. | 6.183 | 20 | 0.000 | 1.714 | 1.14 | 2.29 |
| 5. The use of computers makes me understand more the Science Subject. | 3.980 | 20 | 0.001 | 1.095 | 0.52 | 1.67 |
| 6. It is easier to learn from using computer than from the Science book. | 1.943 | 20 | 0.066 | 0.476 | -0.04 | 0.99 |
| 7. I know what I am expected to do with the computer in the Science class. | 2.092 | 20 | 0.049 | 0.333 | 0.00 | 0.67 |
| 8. The Science class in the computer lab is well organized. | 4.930 | 20 | 0.000 | 1.143 | 0.66 | 1.63 |

*Critical t with 20 degrees of freedom = 1.725*

Results in Table 3 revealed that, at significance level of α = 0.05, the one-tail one-sample t-tests were all statistically significant for all items, except one item in the mathematics subject (item 6). The values of observed t calculated and reported in Table 7 for all items were greater than the critical t value of 1.725 indicating that the hypothesis $\mathbf{H_{A1}}$ is accepted. This clarifies that students had positive attitudes towards the use of ICT in mathematics and science subjects.

As mentioned in section 3.6, both mathematics and science lessons design included activities followed by prompt feedback and repetition. As the operant conditioning theory assumes, positive reinforcement increases students' favourable attitudes towards an activity (Mensah, Okyere & Kuranchie 2013). Additionally, the design of the software included different modes of media such as audio that accompanied on-text screen, which was found to support students' perceptual preferences and learning styles (Crews 2004). As with previous studies, the use of animations in both mathematics and science lessons could have also contributed to students' increased enjoyment when using ICT (Tüysüz 2010).

However, for item 6 in mathematics, the observed t was 1.596, which is smaller than the critical t value of 1.725, indicating that the hypothesis $\mathbf{H_{A1}}$ cannot be accepted for this item. This suggests that students were more likely to believe that learning from the computer is not easier than the mathematics book. This could be caused by the way the order of the learning material was presented. As mentioned in section 3.6, the "Personal Math Trainer" started by presenting to students a problem and relied on their inquiry skills to draw conclusions. Without the aid of the teacher, low ability students may find this method hard to follow, which might have affected their attitudes towards the learning with ICT in favour to the traditional learning method (Crews 2004).

#### 4.1.2.2. $H_{A2}$: There is a Significant Difference at Level in the Attitudes of Grade Three Students Towards the Use of ICT Between Mathematics and Science Subjects

To test this hypothesis, paired samples t tests were performed on each individual item in the questionnaire as the main aim is to find out whether there is a significant difference between mean scores of attitudes of students for mathematics and mean scores of attitudes of students for science. Since the composite factors were different in content for each subject, they cannot be used to compare the two subjects to each other. Rather, the individual items were used, as shown in Table 4. Here, the paired-samples t test is an appropriate statistic to use because the attitude scores come from matched pairs of participants (students). That is, attitude scores were collected from the same individuals as each student gives two scores, one for each of the two subjects (Greene & d'Oliveira 2005).

*Table 4: Paired-Samples T Tests for Positive Attitudes Towards Using ICT Between Mathematics and Science*

| | Paired Differences | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 95% CI of the Difference | | | | |
| Pairs of Attitudes | | | | Lower | Upper | t | DF | Sig. (2-tailed) |
| 1. I enjoy the Maths/Science class when it is the computer lab. | -0.476 | 0.750 | 0.164 | -0.817 | -0.135 | -2.911 | 20 | 0.009 |
| 2. The use of Computers in the Maths/Science class doesn't make me nervous. | -0.524 | 2.462 | 0.537 | -1.645 | 0.597 | -0.975 | 20 | 0.341 |
| 3. The activities in the Maths/Science lesson on the computer are fun and interesting. | -0.190 | 1.401 | 0.306 | -0.828 | 0.447 | -0.623 | 20 | 0.540 |
| 4. I can achieve better marks when learning Maths/Science on the computer. | -0.714 | 2.610 | 0.570 | -1.903 | 0.474 | -1.254 | 20 | 0.224 |
| 5. The use of computers makes me understand more the Maths/Science Subject. | -0.333 | 1.426 | 0.311 | -0.982 | 0.316 | -1.071 | 20 | 0.297 |
| 6. It is easier to learn from using computer than from the Maths/Science book. | 0.048 | 1.717 | 0.375 | -0.734 | 0.829 | 0.127 | 20 | 0.900 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7. I know what I am expected to do with the computer in the Maths/Science class. | 0.143 | 0.910 | 0.199 | -0.271 | 0.557 | 0.719 | 20 | 0.480 |
| 8. The Maths/Science class in the computer lab is well organized. | -0.238 | 0.995 | 0.217 | -0.691 | 0.215 | -1.096 | 20 | 0.286 |

From the results reported in Table 4, the researcher could decide that there was a statistically significant difference in the attitudes of grade-three students towards the use of ICT between mathematics and science subject for item 1 only, as the p value = 0.009, which is less than the significance level of $\alpha = 0.05$. Recalling Table 2, it could be seen that the mean score of attitudes in science was larger than the mean score of attitudes in mathematics, M = 3.76 and 3.29, respectively. This indicates that students significantly enjoyed the science class more than the mathematics class when using the computer lab. Again, this might have been influenced by the type of material presented to them through the online software. In the mathematics class, the images were mainly of plane geometric shapes with a visual presentation on how to find the perimeter. Few of the shapes were transformed to real life examples, such as picture frames and farm fences. Additionally, students only had to watch and listen to the explanation with few opportunities of interaction. On the other hand, the science lesson resembled more an astronomy lab where students had to “view” the moon from different positions and record their observations. Thus, students in science had more chances to be active learners (Merrill 2002).

However, it is important to keep in mind that the attitudes regarding item 1 were positive in both mathematics and science. That is to say, that even though there was a significant difference on students’ attitudes for item 1, students’ have enjoyed both classes.

There were no other significant differences in the attitudes of grade-three students towards the use of ICT between mathematics and science subject for the other items (p values > 0.05), indicating that **$H_{A2}$** is rejected for these attitudes. This could be caused by the similarity in the conditions in which mathematics and science classes were conducted, such as the use of the same computer lab and same software. Qualitative analysis in section 4.2 further investigates the results and relates them to the classroom observation results.

#### 4.1.2.3. HA3: There is a Significant Difference in the Mathematics Subject Between the Average Achievements of Grade Three Students Using ICT and Without

This hypothesis was tested using a two-way Mixed ANOVA, which allows to test whether participants perform differently in different experimental conditions (Greene & d'Oliveira 2005).

In this case, the two-way mixed ANOVA model has two independent variables: one within-subjects and one between-groups. The within-subjects factor is the average achievement of grade three students in mathematics and the between-groups factor is the method of learning (ICT or Traditional).

The two-way mixed ANOVA examined the effects of using ICT on students' mathematics test scores before and after the learning process using the ICT. Table 5 shows the means of the conditions of the design. There was an interaction between mathematics learning and method of learning, which tells about the magnitude of the effect, in this case 'medium' effect (Gamst, Meyers & Guarino 2008). Descriptive statistics in Table 5 showed that both learning techniques caused a leverage in post-test scores over the pre-test scores.

*Table 5: Descriptive Statistics of Conditions of the Study Design - Mathematics*

| | Learning Method | Mean | SD | N |
|---|---|---|---|---|
| | ICT | 2.05 | 2.012 | 21 |
| | Traditional | 2.30 | 1.689 | 20 |
| | Total | 2.17 | 1.843 | 41 |
| | ICT | 6.57 | 3.059 | 21 |
| | Traditional | 8.10 | 1.744 | 20 |
| | Total | 7.32 | 2.593 | 41 |

Student's achievement in mathematics significantly improved after taking the test regardless of the learning method, with mean pre-test score (M = 2.17) and mean post-test score (M = 7.34). In contrast, there was no significant main effect of learning method on students' achievement scores in the mathematics test, with students showing similar average test scores for ICT (M = 4.31) and traditional (M = 5.20), indicating that $\mathbf{H_{A3}}$ is rejected.

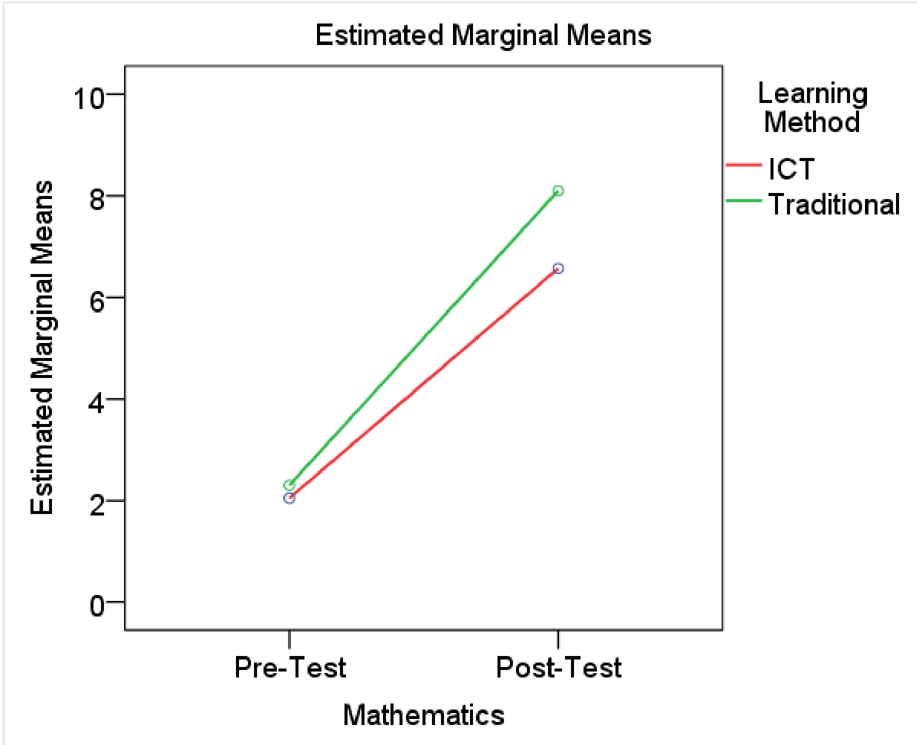


*Figure 9: Estimated Marginal Means Line Graph of Learning Methods against Maths Test*

From looking at the graph in Figure 9, we can see that both learning methods showed a similar attitude of students' achievements.

#### 4.1.2.4. $H_{A4}$: There is a Significant Difference in the Science Subject Between the Average Achievements of Grade Three Students Using ICT and Without

Similar to the previous hypothesis, this hypothesis was tested using a two-way Mixed ANOVA. The within-subjects factor is the average achievement of grade three students in science and the between-groups factor is the method of learning (ICT or Traditional).

The two-way mixed ANOVA examined the effects of using ICT on students' science test scores before and after the learning process using the ICT. Table 6 shows the means of the conditions of the design. There was no interaction between science learning and method of learning.

*Table 6: Descriptive Statistics of Conditions of the Study Design - Science*

| | Learning Method | Mean | SD | N |
|---|---|---|---|---|
| | ICT | 1.62 | 1.910 | 21 |
| | Traditional | 2.05 | 1.701 | 20 |
| | Total | 1.83 | 1.801 | 41 |

| | | | | |
|---|---|---|---|---|
| Post-Test Science Score | ICT | 7.52 | 2.112 | 21 |
| | Traditional | 7.70 | 1.559 | 20 |
| | Total | 7.61 | 1.842 | 41 |

There was a main effect for science test. Student's achievement in science significantly improved after taking the test regardless of the learning method, with mean pre-test score (M = 1.84) and mean post-test score (M = 7.61). In contrast, there was no significant main effect of learning method on students' achievement scores in the science test, with students showing similar average test scores for ICT (M = 4.57) and traditional (M = 4.88), indicating that **$H_{A4}$** is rejected.

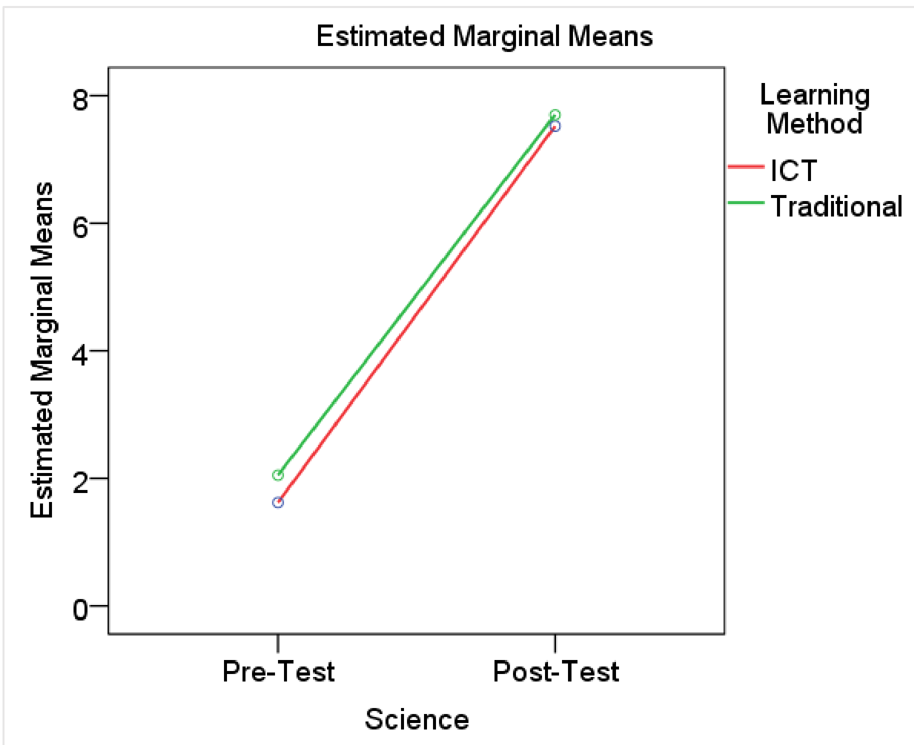


*Figure 10: Estimated Marginal Means Line Graph of Learning Methods against Science Test*

From looking at the graph in Figure 10, we can see that both learning methods showed a similar attitude of students' achievements.

#### 4.1.2.5. $H_{A5}$: There is a Significant Difference in the Average Achievement of Grade Three Students Between Mathematics and Science Using ICT

This hypothesis was tested by performing a two-way mixed model (Repeated Measures) ANOVA using Progress (Mathematics and Science) and Method of Learning (Traditional and

ICT) to find if there is a significant difference between progress of mathematics and progress of science accounting for the method of learning.

**Mathematics Progress = Pre-test Score – Post-test Score**

**Science Progress = Pre-test Score – Post-test Score**

The test revealed a significant main effect of progress, F(1,39) = 5.152, p = 0.029, $\eta_p^2$ = 0.117 (Table 8), with a mean progress score of mathematics of 5.16 and mean progress score of science of 5.78, indicating that students significantly progressed more in science than in mathematics, regardless of the method used.

*Table 7: Descriptive Statistics of Conditions of the Study Design - Progress (Mathematics and Science)* Learning Method*

| | Learning Method | Mean | Std. Deviation | N |
|---|---|---|---|---|
| | Traditional | 5.8000 | 1.43637 | 20 |
| | ICT | 4.5238 | 2.08852 | 21 |
| | Total | 5.1463 | 1.89157 | 41 |
| | Traditional | 5.6500 | 1.13671 | 20 |
| | ICT | 5.9048 | 1.60950 | 21 |
| | Total | 5.7805 | 1.38766 | 41 |

There was also a significant interaction between progress and method, F(1,39) = 7.969, p = 0.007, $\eta_p^2$ = 0.170 (Table 8). From Table 7 and Table 8, we can see that the mean progress score of mathematics has decreased when ICT was used ($M_{traditional}$ = 5.80 and $M_{ICT}$ = 4.52), while the mean progress score of science has improved when ICT was used from 5.65 to 5.91. The interaction effect was significant, with a magnitude of 0.170, indicating that the effect was weak.

*Table 8: Tests of Within-Subjects Contrasts*

| Source | Progress | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| Progress | Linear | 7.761 | 1 | 7.761 | 5.152 | .029 | .117 |
| Progress * method | Linear | 12.005 | 1 | 12.005 | 7.969 | .007 | .170 |
| Error(Progress) | Linear | 58.751 | 39 | 1.506 | | | |

Based on the results of the mixed model ANOVA, a paired-samples t test was conducted to detect significant differences between mean progress score of mathematics and mean progress score of science (Table 9). The test revealed that when traditional learning methods were applied, students were likely to progress in mathematics and science similarly, t = 0.396 and p value = 0.697. On the other hand, when ICT was applied, the test was significant, t = -3.567 and p value = 0.002, indicating that $\mathbf{H_{A5}}$ should be accepted, and we can conclude that there was a significant difference between mean progress score of mathematics and mean progress score of science under the use of ICT. That is, under the use of ICT, students had higher mean progress score in science (M = 5.90) than in mathematics (M = 4.52), with a mean difference of 1.38.

*Table 9: Paired Samples t Test*

| Learning Method | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Traditional | diff_math - diff_sci | .15000 | 1.69442 | .37888 | -.64301 | .94301 | .396 | 19 | .697 |
| ICT | diff_math - diff_sci | -1.38095 | 1.77415 | .38715 | -2.18854 | -.57337 | -3.567 | 20 | .002 |

These results align with the findings of the attitudes' questionnaire as well as the observation. Students had positive attitudes towards the use of ICT in both mathematics and science except for item 6 in mathematics, indicating that students were more likely to believe that learning from computer is not easier from the mathematics book.

This might have been influenced by the design of the CAI. As described in section 3.6, the mathematics lesson started by presenting students with a problem and relied on their inquiry skills to draw conclusions. Without the aid of the teacher, low ability students may find this method hard to follow, which might have affected their achievement scores (Crews 2004). Additionally, the mathematics lessons included mainly still images representing geometric shapes with few relations to real-life. On the other hand, the science lessons resembled an astronomy lab where students had to "view" the moon from different positions and record their observations. Students in science had more chances to be active learners (Merrill 2002).

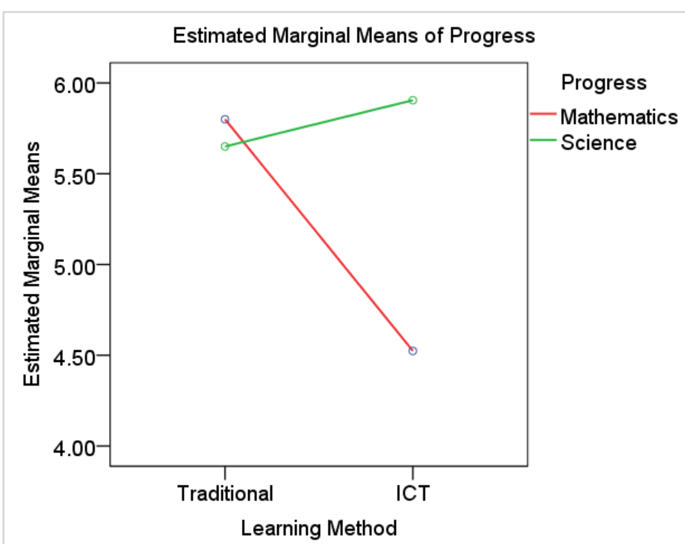


*Figure 11: Estimated Marginal Means Plot of Progress*

Figure 11 illustrates the Estimated Marginal Means for progress against the learning method. It can be seen from the figure that the mean scores of students significantly decreased when using ICT in mathematics, while their mean score increased when using ICT in science.

### 4.1.3. Summary of Quantitative Analysis

According to the quantitative data analysis, it can be implied that students had positive attitudes towards the use of ICT in mathematics and science in general. However, students had low attitudes in mathematics regarding their beliefs in that learning mathematics using the computer is easier than using the mathematics book. When comparing students' attitudes in both subjects, it was found that there is no significant difference, except for one item regarding students' enjoyment, where students were found to enjoy the science class more than mathematics. Thus, $\mathbf{H_{A1}}$ was accepted for all the questionnaire items except item 6, while $\mathbf{H_{A2}}$ was rejected for all questionnaire items except item 1.

On the other hand, the analysis of pre- and post- tests showed that there was no significant main effect of learning method (ICT or Traditional) on students' achievement scores in the mathematics subject as well as the science subject, rejecting $\mathbf{H_{A3}}$ and $\mathbf{H_{A4}}$. However, when comparing students' progress in both subjects, there was a significant difference between mean progress scores in mathematics compared to mean progress scores in science when using ICT. While students mean progress scores increased when using ICT in science, they decreased when using ICT in mathematics. Thus, $\mathbf{H_{A5}}$ was accepted, indicating that students benefited from the use of ICT in science more than mathematics.

## 4.2. Qualitative Results

In order to better understand students' attitudes towards the use of ICT as well as investigate what might affect their attitudes and link it to students' achievement, four classroom observations were conducted in the computer lab; two when students were using the online software for mathematics and another two for science. Qualitative data in this research is important in order to explore anticipated themes as well as emerging ones (Lofland & Lofland 2006). Data from the classroom observation have been collected and categorized according to the type of behaviour for both students and teachers. Additionally, the frequency of some repeated behaviours has been recorded. Table 10 shows a summary of observed behaviours and the number of occurrences in both mathematics and science classes in the computer lab.

*Table 10: Summary of Observed Behaviors*

| **Category** | **Behaviour** | **Frequency (Average)** | |
|---|---|---|---|
| | | Mathematics (N = 21) | Science (N = 21) |
| | Student confused on what to do with the computer (looking around for help, asking the teacher what to do) | 12 (57%) | 7 (33%) |
| | Student off task (talking to peers, out of seat) | 5 (24%) | 6 (29%) |
| | Student approaching teacher | 1 (5%) | 0 (0%) |
| | Student asking questions regarding the meaning of words (To teacher or to peers) | 7 (33%) | 3 (14%) |
| | Student asking lesson-related questions (To teacher or to peers) | 10 (48%) | 5 (24%) |
| | Student withdrawn or inattentive | 1 (5%) | 1 (5%) |
| | Student feeling nervous (repetitive motor movements, nail biting, turning in chair) | 2 (10%) | 2 (10%) |

The researcher's experience (more than 10 years) in teaching elementary students, helped her form a base for the observation through the anticipated themes. However, the researcher ensured that any behaviour that may be have influence on the research scope was recorded. After recording all the observed behaviours, they were categorized and tabulated.

In all observed classes, students arrived to the computer lab in a line. Each student sat in his/her designated place. In the mathematics classes, the teacher entered the lab and directly asked students to open the online software and login with their accounts. Few students did not remember their login credential and the teacher assisted them. While students were logging in, the teacher asked them to choose the assigned lesson and start it. After a while, while students were already working on the lesson, the teacher reminded students that they have to wear their headphones and listen carefully to the instructions in the lesson in order to be able to solve the questions. On the other hand, the science teacher waited until all students were seated and then asked them to turn to face her and pay attention. She then asked them to log in and choose the assigned lesson. She also reminded them that the "computer" will be responsible of explaining the lesson for them and that they need to pay attention. She also pointed out that students can raise their hand when they are stuck in a step but that they need first to try their best without help.

In general, all observed classes had minimal disruptive behaviour and most of the students were engaged in the computer activities. However, more than half of the students (12 out 21) in the mathematics class were confused specially at the beginning of the lesson. Few students raised their hands to ask for the teacher assistance while others looked at their peers' screens. The number of confused students was less in the science classes (7 out 21). The difference in the number of confused students in both classes might be due to the way the teacher gave instructions at the beginning of the class. As the literature suggests, teachers play a critical role in creating a suitable environment to support ICT (Osborne & Hennessy 2003). However, sometimes the teachers retreat from their roles when ICT is in use. For example, a study on teachers using ICT in science found that teachers do not guide students on selecting the learning tasks (Webb 2005). This observation was found in the mathematics as well as the science lesson in our study, which might also be the reason of the low attitude of students in item 7 "I know what I am expected to do with the computer in the Maths/Science class" of the questionnaire as shown in section 4.1.1

Other students (5 in mathematics and 6 in science) were off task. Some students were talking to their peers while other were walking around the lab. This behaviour could be out of confusion or boredom. Only one student in the mathematics class was seen approaching the teacher to ask for help. Few students (3) asked the teacher the meaning of some words in the science classes, while the number was higher in mathematics (7). Similarly, many students asked questions related to their understanding of the lesson (10 in mathematics and 5 in science). Again, the teacher's pedagogy plays a crucial role in students' learning. It is worth mentioning at this point that ICT cannot replace all other classroom activities. The teacher should balance and integrate the use of ICT with other pedagogies to provide greater learning benefits. The use of ICT in the computer lab should be linked with other activities either during the ICT-based lesson, before, or after (Condie & Munro 2007). This result also aligns with the attitudes questionnaire where the attitudes of students were relatively low in item 6 in mathematics "It is easier to learn from using computer than from the Maths". These results indicate the students required the teacher's help in both lessons, but more so in mathematics, which may justify the difference in students' progress in both subjects.

Only one student in both the mathematics and science classes was inattentive and withdrawn, which the teacher said is a common behaviour of that student in all classes. Additionally, two students in the mathematics class and two in the science class showed signs of nervousness such as rotating the chair and nail biting. However, this kind of behaviour might be due to other reasons such as anxiety.

All students worked at their own pace and had enough time to complete all the assigned activities. Students who finished earlier were given access to an educational game that is related to the subject.

## 4.3. Summary of Data Analysis

This section summarizes the results of the research hypotheses and provides additional discussion of outcomes.

### 4.3.1. Students Attitudes Towards the Use of ICT in Mathematics and Science

The analysis of the attitudes questionnaire revealed that students had positive attitudes towards the use of ICT in mathematics and science subjects in general. The descriptive analysis of the questionnaire in both mathematics and science showed that students had higher positive attitudes in items referring to enjoyment and fun when using the computer; whereas attitudes scores were lower with items referring to students’ understanding of procedures and clarity of instruction. Additionally, the analysis of the mathematics questionnaire suggests that students were more likely to believe that learning from computer is not easier than the mathematics book. On the other hand, when comparing students’ attitudes towards the use of ICT between mathematics and science, only the comparison of one item representing enjoyment was found to be significant, indicating that students significantly enjoyed the science class more than the mathematics class when using the computer lab. However, the results from the analysis of the attitudes questionnaire should be considered with caution, as some items indicated poor reliability. The qualitative data agree with the quantitative data of the study regarding students’ attitudes, revealing that the majority of the students in both mathematics and science classes were engaged in the computer activities, except at the beginning of the lesson, when some students looked confused and approached the teacher or their peers for instructions.

These results are consistent with earlier research. Previous studies affirm that the use of ICT in the classroom has a positive effect on students' attitudes towards learning in general and the subject taught in particular (Webb 2005; Balanskat, Blamire & Kefala 2006; Kahveci & Imamoglu 2007; Kubiatko 2010; Ong, Foo & Lee 2010; Ziden et al. 2011). However, even though the introduction of ICT in the classroom can have a motivating impact on students, depending on ICT by itself to create a more effective learning environment is not sufficient. Factors such as teachers' language and pedagogy should be taken into consider when planning the use of ICT (Condie & Munro 2007).

#### 4.3.2. The Impact of ICT on Students' Achievement in Mathematics and Science

The analysis of the pre- and post- tests imply that there is a positive link between the use of ICT and students' achievement in mathematics and science, but was not considered statistically significant. These results agree with some of the previous studies regarding ICT impact on students' achievement in mathematics and science (Harrison et al. 2002; Reimer & Moyer 2005; Balanskat, Blamire & Kefala 2006; Machin, McNally & Silva 2006). However, when comparing students' progress in both subjects, there was a significant difference between the mean progress scores in mathematics compared to the mean progress scores in science when using ICT. While students mean progress scores increased when using ICT in science, they decreased when using ICT in mathematics. This indicates that science subject benefited from ICT more than mathematics, agreeing with previous comprehensive studies investigating the impact of ICT on different subjects, where significant effect was usually found in English subject, with less significant effect in science, and much less or none at all in mathematics in different key stages (Harrison et al. 2002; McNally & Silva 2006).

As Balanskat, Blamire and Kefala (2006) suggest, there is a need to understand the underlying reasons that might have caused the digital disadvantage in these subjects, especially mathematics, in those specific situations and circumstances. In this study, ICT was used as the method of instruction without teacher's intervention except for clarifying some terms or explaining procedures. The qualitative analysis of the classroom observation revealed that students were in need of the teacher's guidance and intervention when using the CAI tool, more so in mathematics than in science.

# 5. Chapter Five:
# Conclusion

This chapter portrays the conclusion of this research, providing a summary of the study, recommendation, implications, limitations, and the scope for further study.

## 5.1. Summary of the Study

The aim of this research was to study the impact of ICT in the study of mathematics and science and to find whether there is a difference in the attitudes and achievement of students in both subjects. The basic learning theories were described in order to understand how students learn and how they perceive their learning, especially when ICT is used to aid instruction. This formed a base to describe the design of the ICT instrument used for instruction in the study (CAI). It also provided the researcher the essential background needed to conduct the classroom observation and describe the conditions of the study according to learning theories.

The literature was explored in order to investigate how ICT contributes to mathematics and science, indicating that both subjects benefit from ICT in different ways and to different extents (Condie & Munro 2007). Many studies signify a positive link between students' exposure to technology and their performance and attitudes in mathematics and science (Higgins et al. 2005; Underwood 2006; Kahveci & Imamoglu 2007; Ong, Foo & Lee 2010; Delen & Bulut 2011). However, other studies revealed that students performed better in science than in mathematics when using ICT (Harrison et al. 2002; Machin, McNally & Silva 2006). On the other hand, the contribution of ICT differs from a subject to another. For instance, ICT provides mathematics with tools such as animations, graphical representations and virtual manipulatives. Whereas science benefits from a wider range of tools such as virtual labs, data capture and logging tools, simulators, databases and spreadsheets, graphing tools, presentation tools, and digital microscopes.

This study followed a mixed methods approach. The participants of the study were grade-three students in a private school in Dubai. A questionnaire was designed for the purpose of the study and administered to measure students' attitudes towards the use of ICT in mathematics and science. Additionally, pre- and post- achievement tests were administered to measure students' achievement in mathematics and science with the use of ICT and without. A group of analysis were conducted in order to find whether a school subject benefits more from ICT than another. A classroom observation was also performed in order to investigate students' behaviour in the computer lab and relate it to the quantitative results of the questionnaire and achievement tests.

The analysis of the attitudes questionnaire revealed that students had positive attitudes towards the use of ICT in mathematics and science subjects in general. When comparing students' attitudes in both subjects, it was found that there is no significant difference, except for one item regarding students' enjoyment, where students were found to enjoy the science class more than mathematics. The qualitative data revealed that the majority of the students in both mathematics and science classes were engaged in the computer activities, except at the beginning of the lesson, when some students looked confused and approached the teacher or their peers for instructions.

The analyses of the pre- and post- tests imply that there is a positive link between the use of ICT and students' achievement in mathematics and science, but it was not considered statistically significant. The analyses also revealed that students significantly progressed more in science than in mathematics when using ICT, compared to their progress when using the traditional method. This indicates that science subject benefited from ICT more than mathematics, agreeing with previous comprehensive studies investigating the impact of ICT on different subjects, where significant effect was usually found in English subject, with less significant effect in science, and much less or none at all in mathematics in different key stages (Harrison et al. 2002; McNally & Silva 2006). The qualitative analysis of the classroom observation revealed that students were in need of the teacher's guidance and intervention when using the CAI tool, more so in mathematics than in science.

## 5.2. Key Findings

The key findings of this research are summarized as follows:

- Students had positive attitudes towards the use of ICT in the computer lab in both mathematics and science subjects in general. Previous studies agree with this finding in both mathematics (Reimer & Moyer 2005; Nguyen, Hsieh & Allen 2006; Kahveci & Imamoglu 2007) and science (Osborne & Hennessy 2003; Tüysüz 2010).
- Students had more positive attitudes in questionnaire items referring to enjoyment and fun when using the computer in both mathematics and science. Previous studies support this

finding regarding ICT impact on students' enjoyment and motivation (Mork 2005; Kahveci & Imamoglu 2007; Park, Khan, & Petrina 2009; Tüysüz 2010).

- Students had less positive attitudes in questionnaire items referring to students' understanding of procedures and clarity of instruction. Moore (2005) states that students' lack of understanding of procedures has a negative effect on their attitudes towards the use of ICT.
- Students were more likely to believe that learning from computer is not easier than the mathematics book.
- The use of ICT increased students' achievement scores in both mathematics and science. But when compared to the traditional method of teaching, this impact was not considered statistically significant. This finding implies that in order to best benefit from ICT in classroom, pedagogies as well as CAI design should be further investigated (Harrison et al. 2002; Reimer & Moyer 2005; Balanskat, Blamire & Kefala 2006; Machin, McNally & Silva 2006).
- When comparing students' progress in mathematics and science when using ICT, the mean progress scores of mathematics decreased, while the mean progress scores in science increased. This indicates that science benefited from ICT more than mathematics, which aligns with previous studies investigating the impact of ICT on different subjects (Harrison et al. 2002; McNally & Silva 2006).

## 5.3. Implications

Even though the scope of this study was relatively narrow, it can still contribute to the implementation of theoretical principles of learning. The students' attitudes questionnaire as well as the classroom observations implied that more emphasis should be given to lesson planning and pedagogies when using ICT. The teacher should assume the role of a facilitator without ignoring his/her role leading and directing the class. Students may feel lost when using ICT without the guidance of a teacher, which may result in students' loss of engagement and interest in learning. Teachers should ensure that students are aware of the direction and anticipated outcomes of their learning process (Moore 2005).

Moreover, knowing that ICT has a positive impact on students' achievement, it is important to direct research to address the factors that can maximize the benefits of such implementation.

Some of these factors include teachers' attitudes towards the use of ICT as well as their confidence and skills in using it, the pedagogy used, and the availability of technical support (Moore 2005). Additionally, the use of blended learning rather than relying on ICT alone as a method of instruction could prove to be more effective.

When studying whether one school subject benefits from ICT more than another, it can be concluded that each subject benefit from ICT in a "different" way, employing different tools and technology. However, the "extent" of which a subject can benefit from ICT highly depends on teacher's lesson planning and the pedagogies employed when using ICT. Moreover, more emphasis should be placed on the design of CAI to provide tools that are built according to learning theories to maximize students' learning outcomes and motivation.

## 5.4. Recommendations

According to the results of the study, the following recommendations can be considered:

- **For Policy**
  - Teachers should be offered continuous training to use ICT tools effectively in the classrooms. Studies show that the greatest impact of ICT on students' attainment and attitudes was found when teachers were confident and experienced ICT users (Balanskat, Blamire & Kefala 2006).
  - More investment should be directed to the developing of CAI tools that consider students' cognitive development and learning styles (Crews 2004).
- **For Practice**
  - Teachers should remain central to the learning process by creating a suitable environment to support ICT. Even though the use of ICT shifts the role of the teacher to that of a facilitator, teachers should still act as the leader of the classroom (Osborne & Hennessy 2003).
  - The teacher's pedagogy plays a crucial role in students' learning. ICT cannot replace all other classroom activities. The teacher should balance and integrate the use of ICT with other pedagogies to provide greater learning benefits. The use of ICT should produce pedagogical changes that are aligned with the $21^{st}$ century pedagogy (Law 2009).

- Using ICT in the classroom requires thoughtful and methodical planning. Studies show that students lose focus when lessons are not well-planned for, which results in lower achievement (Webb 2005).

- **For Research**
  - Future research should be directed to the study of the factors that can maximize ICT impact on education.

## 5.5. Limitations

The findings of this study are limited since they report results from only two classrooms in a short period of time and a limited number of observed classes. Additionally, the use of ICT was limited to its use in the computer lab and did not consider other uses in the classroom and blended learning. Moreover, results from the attitudes questionnaire may have been affected by students' perception of anonymity of the survey. Even though the researcher assured the students that their answers were anonymous, some students may have chosen the responses that their teachers would like to hear.

The attitudes' questionnaire was built for the purpose of this study. The results of the exploratory factor analysis (EFA) indicated that some items in the questionnaire had poor reliability. However, the questionnaire had only eight items and was administered to a small sample size. This questionnaire can be improved by adding more items and administering it to a bigger sample (Henson 2001). Additionally, questionnaire factors regarding students' attitudes towards the subject itself should be included as items in the questionnaire to find relations between students' attitudes towards ICT in a subject and their attitudes towards the subject itself.

The qualitative data in this study was used to clarify and supplement the quantitative results. However, additional qualitative measurements could be used to provide better insights and explanations of the findings, such as teachers' and students' interviews as well as teachers' attitudes survey (Creswell 2013).

Another problematics issue with the study of the impact of ICT, is that it is hard to quantify the impact of ICT use in a learning setting. Even though in most of the studies there is a positive link between the use of ICT and students' attainment and attitudes, it is not possible to eliminate the effect of other elements in the learning environment. Therefore, concluding a direct connection between ICT and students' performance from simple correlations can be deceptive (Balanskat, Blamire & Kefala 2006; Condie & Munro 2007).

Even though the findings of this study cannot be generalized, this project provides insights of how ICT can benefit school subjects differently and serves as a foundation of future research.

## 5.6. Scope for Further Study

Many studies on the effect of ICT on particular subjects are based on small-scale studies that lack the use of standardized tests and offer only a 'snapshot' of the situation. Therefore, there is a need to undertake more systematic and longitudinal research, that uses rigid measures of ICT impact as well as combine quantitative and qualitative data in order to determine the long-term impact of ICT on different subjects (Condie & Munro 2007).

This research can be used as a base for future research specially in the Arab countries. Most of the research that examines the link and compares between the use of ICT and students' attainment in different subjects is based in Europe and England in particular. Governments should seek to understand the effect of investment in ICT on education in different settings. Future research may investigate whether ICT resources should be directed to subjects or phases where ICT has greater impact, ignoring other subjects where ICT does not pay off. Or whether applying remedial intervention to disadvantaged subjects can improve their benefit from ICT. Another point worth investigating is to explore teachers' practices and strategies in subjects were ICT has a greater impact in addition to other factors that may influence the effective use of ICT (Balanskat, Blamire & Kefala 2006).

Additionally, future studies can investigate how can ICT benefit the same subject differently. For example, some abstract concept that are difficult for students to gasp may benefit more from the use of ICT than other concepts that require students' active engagement. Moreover, the effect of the frequency of ICT use as well as its order can be further investigated.

## 5.7. Concluding Note

The use of ICT in the teaching and learning processes improves students' engagement and therefore improves knowledge retention. ICT was found to have increased benefits on subjects such as mathematics and science which require visual, audio and video representations. Moreover, ICT can help students comprehend different concepts by linking them to real-life experiences

(Ziden et al. 2011). Many computer applications such as virtual manipulatives in mathematics and virtual simulators in science provided educators with tools that can be used for instruction when conventional methods cannot be applied or where there is a shortage of laboratories or equipment (Tüysüz 2010).

However, to increase the positive impact on education, ICT must be supported with adequate instructional pedagogies as well as detailed lesson planning. Additionally, schools must strive to create a school culture where ICT is used among all teachers, and where continuous training is offered to teachers of all subjects.

The results of this study imply that science benefited more from ICT than mathematics. According to this research, the main factors that might have caused one subject to benefit more than the other are the design of the ICT tool, including the type of material presented and the order of material, the teacher's pedagogy, and the subject matter itself. All these factors require further investigation in order to exploit the full potentials of ICT as a pedagogical tool.

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# Appendices

## Appendix A ICT Contribution in Education

The use of computers in education has been proven to have a positive impact on students' outcomes. For example, the use of simulations and animations allow students to understand abstract concepts through a graphical representation of processes. Developers are emphasizing on the use of gamification to improve students' decision-making skills and team work. Similarly, technologies such as digital video and photography engage students, encourages collaboration and communication, and provides customized opportunities for special needs students. Short videos can also be used by teachers to present the practical part of the lesson to students who missed the class (Condie & Munro 2007). Graphing and modelling tools provide the students with a visual representation of gathered data. The instant connection between the activity and the results through animations and interactive assignments allows students to envision processes more clearly (Mork 2005).

Similarly, learning objects are interactive digital tools that include all resources needed to accomplish the learning objectives, such as instruction and assessment components, that guide the students through the process of learning. A study by Kay and Knaack (2007) on the use of learning objects in science subjects for high school students found that the majority of students valued the motivating, engaging, and visual characteristics of learning objects and believed that they had benefited from the tool.

Following are studies that point to the impact of ICT on learners, teachers and pedagogies.

### Impact on Learners

A great deal of literature identifies a positive relation between the introduction of ICT in the classroom and its impact on learning. This includes, for example, the effect on students' achievement, motivation, independent learning, team work, and learning styles (Moore 2005; Balanskat, Blamire & Kefala 2006; Condie & Munro 2007).

Cox et al. (2003) performed an extensive literature review regarding ICT and attainment and found a positive relation between them in most of the curriculum core subjects, namely English, Math and Science where there was a greater focus on investment on ICT resources. The impact was found to be stronger when ICT was used to support language acquisition and specific concepts in Math and Science. Park, Khan and Petrina (2009) pointed out the impact of CAI on students' comprehension in both high and low achievers in Science when combining ICT with teacher support. Harrison et al. (2002) found that even though the connection between ICT and higher scores in national tests compared to the expected ones was only evident in a third of the studies, in none of the comparisons the actual scores were higher than the expected ones when not using ICT. In general, it was found that students in schools that were better equipped with ICT resources achieved better in national and international tests. Such reports can help researchers and policy makers to measure the amount and cost of investment needed to improve students' achievement (Balanskat, Blamire & Kefala 2006).

The benefits of ICT can have an indirect impact on students' achievement. For example, Nguyen, Hsieh and Allen (2006) found that using web-based assessment and practice encouraged students to spend more time in a specific task and therefore, achieve higher levels of understanding. Additionally, Watts and Lloyd (2004) noted that students cared about the work they were producing using the computer and created higher quality documents containing images and fancy fonts. Moore (2005) stated that ICT helps in providing a wide range of educational resources that can be available to all the students at the same time overcoming the lack of physical resources.

All these benefits are better achieved when teachers use ICT to plan and prepare for the lesson as well as deliver it. ICT use should be connected to the curriculum objectives and should be an essential part of the lesson in order to achieve a positive impact on students' achievement (Cox et al. 2003). In other words, there are many factors that influence the impact of ICT on attainment, including the subject being taught, the quality of teaching, and the frequency in which ICT is used in the classroom (Harrison et al. 2003). Another factor that affects researches on ICT and attainment is how 'attainment' is defined. Some studies refer to students' overall performance in standardized tests while others refer to the acquisition of certain skills in a specific subject in what is called "domain-specific cognitive development" (Condie & Munro 2007). In summary, when attainment is studied, it is evident that using ICT can have a positive effect in some settings, with some students, and in some subjects.

On the other hand, there is more positive evidence on the impact of ICT on students' motivation and engagement. The indirect benefits of ICT, sometimes called secondary, include greater collaboration, increased perseverance and concentration, development of critical thinking and problem-solving skills, increased creativity, improved behaviour, and more on-task focus. From the studies, it was found that motivation and engagement increases when certain technologies that contain visual elements are used. This includes overhead projectors, multimedia presentations and interactive whiteboards (Balanskat, Blamire & Kefala 2006; Condie & Munro 2007; Ziden et al. 2011). Teachers usually notice that ICT motivates most of the students, including those who are usually hard to engage by encouraging students to finish their tasks on time, focus on the learning process, and feel proud of their work (Harrison et al. 2002). While increased motivation does not directly improve achievement, the effects of improved motivation are associated with the development of cognitive skills, which in return, are linked to achievement (Condie & Munro 2007).

In a study of the literature on ICT and Science education, Osborne and Hennessy (2003) found that students are more engaged in science activities and discussions when using ICT technologies such as modelling and simulation tools which allow them to be actively engaged and to control their own learning. Virtual laboratories were also found to increase students' engagement by providing prompt feedback and accurate results, and decreasing the amount of experiments preparation. In another study, Nguyen, Hsieh and Allen (2006) found that web-based assessment and practice increased students' confidence in solving math problems and increased their motivation to learn math. Another important benefit of ICT in the classroom is the improved behaviour of students. Moore (2005) stated that students are less troublesome when they are engaged on computer activities.

However, as with attainment, the impact of ICT on motivation can be better studied when educational objectives are clearly identified and connected to the learning activity. Additionally, there is a need for large-scale studies on the direct role of ICT rather than the presented small-scales studies in which generalizations cannot be drawn (Condie & Munro 2007).

Another great benefit of ICT on learners is that students learn independently and at their own pace (Ziden 2011). On the other hand, the use of ICT was also found to increase discussion among students as well as teamwork and collaboration when working on projects, investigations, and problem-solving activities (Balanskat, Blamire & Kefala 2006).

When using ICT, learning becomes more students centred allowing for greater differentiation and providing students with a personalized experience. Additionally, ICT helps teachers identify students' special need by monitoring their work on the computer while performing specific tasks. ICT also helps in identifying students learning needs, such as slow learners, socially or economically disadvantaged, and talented (Balanskat, Blamire & Kefala 2006). Once identified, ICT can encourage special needs students to participate in class, proudly present their work, and improve their confidence (Condie & Munro 2007).

Condie and Munro (2007) also argued that ICT tools can increase students' creativity but yet such benefits are unexploited. Loveless (2009), in a study of technology and creativity, pointed out the various ways in which ICT could be used to increase creativity such as representing imaginative ideas, connecting and collaborating with people and information, creating and transforming media, and evaluating data.

In summary, these studies indicate that ICT can benefit learners from different ages and in various subjects. ICT was found to increase students' achievement when used in connection with the lesson's objectives, motivate students to stay on tasks, reduce disruptive behaviour, teach students to work independently as well as collaboratively, increase self-esteem and self-confidence, allow for greater differentiation to meet students' needs, and integrate different subjects in project-based activities.

**Impact on Teachers**

With the introduction of educational technologies, the role of the teacher has shifted from being the centre of the classroom to being a facilitator and supporter of students' education. Teachers are now responsible of creating an e-learning classroom and provide the students with the resources they need to become active learners. The reasons for this shift are many. First, new technological tools are replacing the more 'traditional' ones such as the overhead projectors and boards. Second, students may no longer be situated in a classroom but distributed in remote locations. Thirdly, the trends in educations shifted from being concerned with knowledge to the development of skills such as critical thinking (Condie & Munro 2007). With this change in education variables, teachers are encouraged to develop their skills in ICT use.

ICT has been found to have a great impact not only on students and learning but on teachers and teaching as well. Among the benefits of using ICT are increased enthusiasm and collaboration.

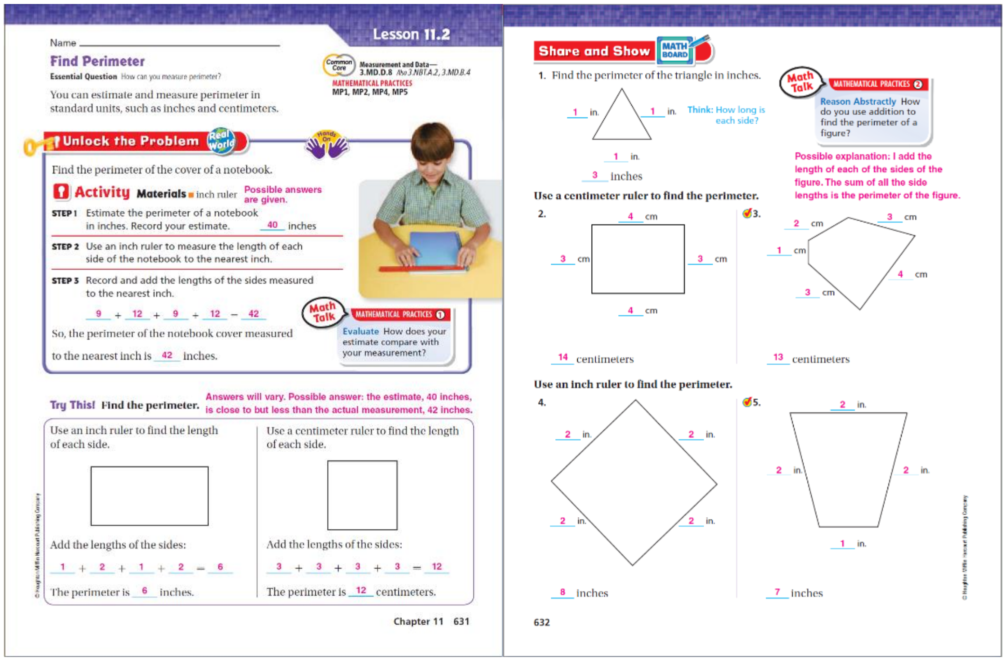
Teachers can use ICT to plan for their lessons more effectively and efficiently. Teachers' confidence and attitudes towards using ICT in the classroom increases when teachers are equipped with powerful ICT tools that aid in the preparation and presentation of their lessons such as their own laptops and smartboards. Similarly, the quality of teachers' work increases since ICT allows for greater collaboration and cooperation between teachers. Additionally, ICT enhances teachers' abilities to prepare their daily lessons, prepare personalized plans for special needs students, present visual materials to students, and enhance assessment. Moreover, it was found that when teachers are connected to the internet or to a local network, their professional development levels and confidence in using ICT increased. In addition to that, connectivity allows teachers to browse learning resources and generate ideas for their lessons (Balanskat, Blamire & Kefala 2006). ICT also makes the process of assessing students' work much easier and faster by providing question banks and instant grading. Teachers can store and manage students' data and provide students and parents prompt feedback which, in returns, improves students' performance (Condie & Munro 2007).

**Impact on Pedagogical Practice**

The impact of ICT on pedagogical practice is not evident as that of teaching and learning practices. We are still in a stage where teachers are not "ICT-confident" and use ICT only to enhance their current teaching methodologies rather than incorporating new ones. The literature suggests that the use of ICT requires a special pedagogical approach in order to improve learning (Balanskat, Blamire & Kefala 2006). ICT pedagogy includes using shared resources, collaborative and autonomous learning, and the teachers being a facilitator rather than an instructor. ICT improves communication, eases monitoring and records management, facilitates the access to resources and information, and builds a standardized organizational structure in the school (Condie & Munro 2007).

Appendix B **Pages Used in the Control Group Lesson Explanation**

## Appendix B.1 Pages Used in Mathematics


Name

Lesson 11.2

Find Perimeter

Essential Question How can you measure perimeter?

Common Core Measurement and Data—3.MD.D.8 Also 3.NBT.A.2, 3.MD.B.4

MATHEMATICAL PRACTICES MP1, MP2, MP4, MP5

You can estimate and measure perimeter in standard units, such as inches and centimeters.

Unlock the Problem Real World

Find the perimeter of the cover of a notebook.

Activity Materials ■ inch ruler Possible answers are given.

STEP 1 Estimate the perimeter of a notebook in inches. Record your estimate. 40 inches

STEP 2 Use an inch ruler to measure the length of each side of the notebook to the nearest inch.

STEP 3 Record and add the lengths of the sides measured to the nearest inch.

9 + 12 + 9 + 12 = 42

So, the perimeter of the notebook cover measured to the nearest inch is 42 inches.

Math Talk MATHEMATICAL PRACTICES 1 Evaluate How does your estimate compare with your measurement?

Try This! Find the perimeter. Answers will vary. Possible answer: the estimate, 40 inches, is close to but less than the actual measurement, 42 inches.

Use an inch ruler to find the length of each side.

Add the lengths of the sides:

1 + 2 + 1 + 2 = 6

The perimeter is 6 inches.

Use a centimeter ruler to find the length of each side.

Add the lengths of the sides:

3 + 3 + 3 + 3 = 12

The perimeter is 12 centimeters.

Chapter 11 631

Share and Show MATH BOARD

1. Find the perimeter of the triangle in inches.

1 in. 1 in. 1 in. Think: How long is each side?

3 inches

Math Talk MATHEMATICAL PRACTICES 2 Reason Abstractly How do you use addition to find the perimeter of a figure?

Possible explanation: I add the length of each of the sides of the figure. The sum of all the side lengths is the perimeter of the figure.

Use a centimeter ruler to find the perimeter.

2. 4 cm, 3 cm, 3 cm, 4 cm — 14 centimeters

3. 2 cm, 3 cm, 1 cm, 4 cm, 3 cm — 13 centimeters

Use an inch ruler to find the perimeter.

4. 2 in., 2 in., 2 in., 2 in. — 8 inches

5. 2 in., 2 in., 2 in., 1 in. — 7 inches

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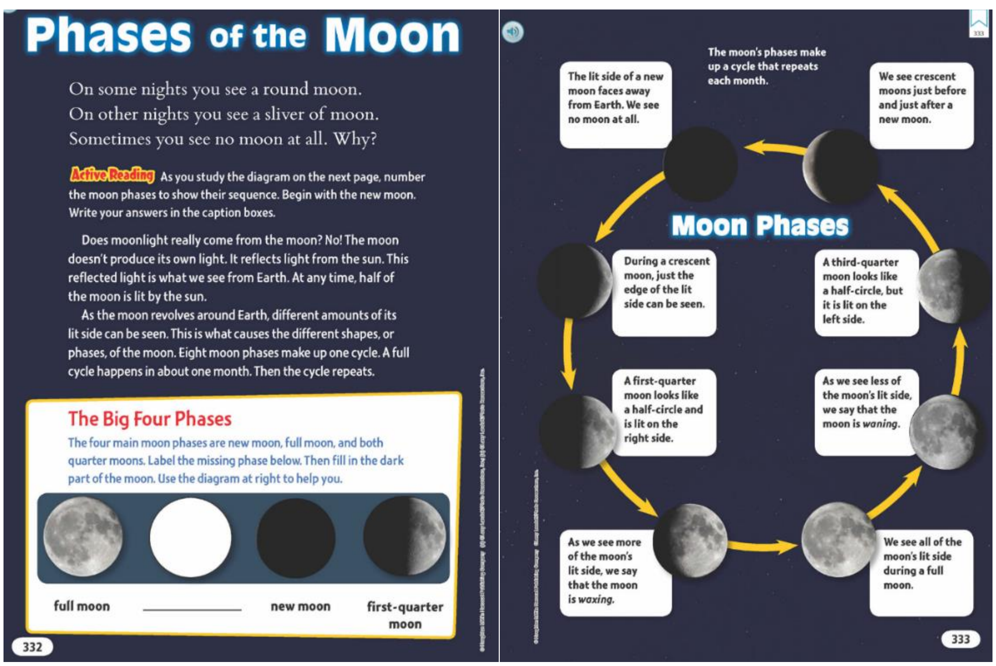
## Appendix B.2 Pages Used in Science


Phases of the Moon

On some nights you see a round moon. On other nights you see a sliver of moon. Sometimes you see no moon at all. Why?

Active Reading As you study the diagram on the next page, number the moon phases to show their sequence. Begin with the new moon. Write your answers in the caption boxes.

Does moonlight really come from the moon? No! The moon doesn't produce its own light. It reflects light from the sun. This reflected light is what we see from Earth. At any time, half of the moon is lit by the sun.

As the moon revolves around Earth, different amounts of its lit side can be seen. This is what causes the different shapes, or phases, of the moon. Eight moon phases make up one cycle. A full cycle happens in about one month. Then the cycle repeats.

The Big Four Phases

The four main moon phases are new moon, full moon, and both quarter moons. Label the missing phase below. Then fill in the dark part of the moon. Use the diagram at right to help you.

full moon ________ new moon first-quarter moon

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The moon's phases make up a cycle that repeats each month.

The lit side of a new moon faces away from Earth. We see no moon at all.

We see crescent moons just before and just after a new moon.

Moon Phases

During a crescent moon, just the edge of the lit side can be seen.

A third-quarter moon looks like a half-circle, but it is lit on the left side.

A first-quarter moon looks like a half-circle and is lit on the right side.

As we see less of the moon's lit side, we say that the moon is *waning*.

As we see more of the moon's lit side, we say that the moon is *waxing*.

We see all of the moon's lit side during a full moon.

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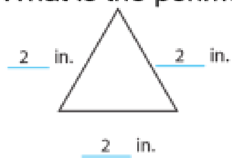
Appendix C **Pre- and Post- Tests**

## Appendix C.1 Mathematics Test

Name: _______________

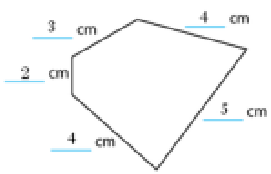
Answer the following question by choosing the right answer:

1. What is the perimeter of this triangle in inches?



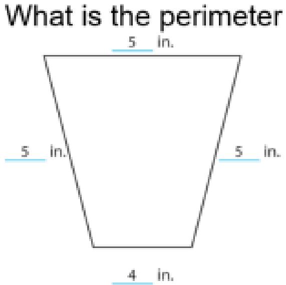

A. ○ 2
B. ○ 4
C. ○ 6
D. ○ 8

2. What is the perimeter of the following shape in centimetres?



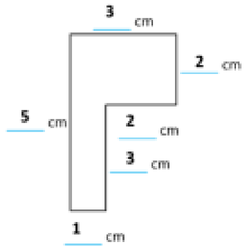

A. ○ 4
B. ○ 18
C. ○ 5
D. ○ 20

3. What is the perimeter of the following shape in inches?




A. ○ 19
B. ○ 10
C. ○ 15
D. ○ 4

4. What is the perimeter of the following shape in centimetres?



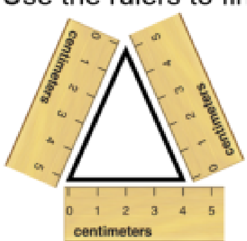

A. ○ 1

B. ○ 15

C. ○ 6

D. ○ 16

5. Use the rulers to find the perimeter of the triangle:



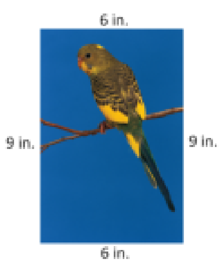

A. ○ 9 cm

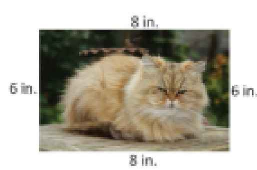
B. ○ 18 cm

C. ○ 14 cm

D. ○ 10 cm

6. Which of the animal photo has a perimeter of 30 inches?




A. ○ None of them

B. ○ The Bird

C. ○ The Cat

D. ○ Both of Them

7. Erin is putting a fence around her square garden. Each side of her garden is 5 meters long. How long is the fence that she should buy?

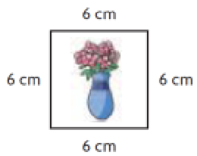
A. ○ 5

B. ○ 10

C. ○ 20

D. ○ 25

8. Kim wants to put trim around a picture she drew. How many centimetres of trim does Kim need for the perimeter of the picture?



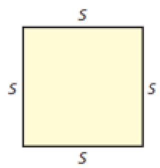

A. ○ 6

B. ○ 12

C. ○ 26

D. ○ 24

9. Vanessa uses a ruler to draw a square. The perimeter of the square is 12 centimetres. How long is the side length of the square?



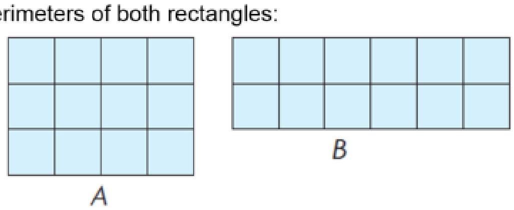

A. ○ 1

B. ○ 2

C. ○ 3

D. ○ 4

10. Tomas drew two rectangles on grid paper. Circle the sentence that best describes the perimeters of both rectangles:




A. ○ Rectangle A perimeter is less than Rectangle B perimeter

B. ○ Rectangle A perimeter is greater than Rectangle B perimeter

C. ○ Rectangle A perimeter is the same as Rectangle B perimeter

## Appendix C.2 Science Test

Name: ________________

1. Earth spins around an imaginary line. Which of these words is the name for the imaginary line around which Earth spins?

   A. ○ axis

   B. ○ orbit

   C. ○ rotation

   D. ○ season

2. One kind of motion takes Earth around the sun. Which of these words is the name for one complete trip around the sun?

   A. ○ innovation

   B. ○ revolution

   C. ○ rotation

   D. ○ vibration

3. The moon takes about 29 days to make one trip around Earth. In this table, Jose recorded the dates on which he saw the full moon.

   Dates of the Full Moon in 2010

   | Dates | Number of Days in the Month |
   | --- | --- |
   | July 26 | 31 |
   | August 24 | 31 |
   | September 23 | 30 |
   | October ? | 31 |

   On which of the following days in October did Jose **most likely**see the full moon?

   A. ○ 18

   B. ○ 22

   C. ○ 26

   D. ○ 30

4. Every night, the lighted part of the moon appears to change slightly by either getting larger or getting smaller. Which of these words describes the moon when it is getting larger?

   A. ○ crescent

   B. ○ gibbous

   C. ○ waning

   D. ○ waxing

5. One of Earth's motions causes it to have four seasons. Which of these motions causes Earth to have four seasons?

   A. ○ revolving

   B. ○ rotating

   C. ○ spinning

   D. ○ vibrating

6. You used a model to study the moon's phases. Which feature of the model was **most**like the way the phases of the moon happen?

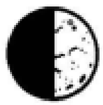
A. ○ the time it took to see all the phases of the moon

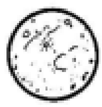
B. ○ the changes in size and shape of the moon's lit area

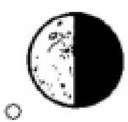
C. ○ the way it showed how Earth moves around the sun

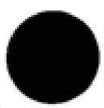
D. ○ the sizes and shapes of the objects used as the moon and sun

7. The lit part of the moon you see from Earth changes shape. Which of these pictures shows how the moon looks when it is on the side of Earth away from the sun?

A. ○ 

B. ○ 

C. ○ 

D. ○ 

8. Kim drew this picture to show how the moon looked one night.

Which word is the term for a moon with this shape?

A. ○ crescent

B. ○ full

C. ○ new

D. ○ quarter

9. The moon looks to be a different size in different phases. Which is the pair of phases in which the moon looks about the same size?

A. ○ full moon and new moon

B. ○ full moon and first-quarter moon

C. ○ new moon and third-quarter moon

D. ○ first-quarter moon and third-quarter moon

10. The shape of the lit part of the moon changes slightly each night. Which of these actions helps cause the changes in the shape of the moon?

A. ○ the turning of Earth on its axis

B. ○ the turning of the sun on its axis

C. ○ the motion of the moon around Earth

D. ○ the motion of the moon around the sun

## Appendix D Reliability and Validity Analysis of the Attitudes Questionnaire

Attitudes were measured by asking the third-grade students eight questions for both subjects; mathematics and science. Students' responses were used in assessing construct validity and internal consistency (reliability). The data was screened for univariate outliers. No out-of-range values were found. In order to assess the construct validity and internal consistency of the questionnaire, exploratory factor analysis (EFA) was used to reduce the number of variables (the eight questions) to a few underlying dimensions. EFA examines the associations between variables, based on the correlations between them, to see if there are underlying factors. EFA allows to find out whether the variables could be grouped into smaller number of composite variables to use to convey as much of the information in the observed/measured variables as possible (Leech, Barrett & Morgan 2005).

EFA was conducted on the eight items with orthogonal rotation (varimax) for each subject, separately. Using mathematics questionnaire responses, the Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = 0.501 ('mediocre' according to Field 2013). Bartlett's test of sphericity $\chi^2$ (28) = 71.247, $p < .001$, indicated that correlations between items were sufficiently large for EFA. An initial analysis was run to obtain eigenvalues for each component in the data. Three components had eigenvalues over Kaiser's criterion of 1 and in combination explained 75.37% of the variance. The scree plot justified retaining three components. Table 11 shows the factor loadings after rotation. The items that cluster on the same components suggest that component 1 represents ICT support for learning, component 2 easiness of use, and component 3 enjoyment.

On the other hand, science questionnaire responses revealed slightly different findings. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = 0.578 ('mediocre' according to Field 2013). However, Bartlett's test of sphericity $\chi^2$ (28) = 29.489, $p = .388$, indicated that correlations between items were not sufficiently large for EFA. When an initial analysis was run to obtain eigenvalues for each component in the data, three components had eigenvalues over Kaiser's criterion of 1 and in combination explained 64.99% of the variance. The scree plot justified retaining three components. Table 11 shows the factor loadings after rotation. The items that cluster on the same components suggest that component 1 represents achievement, component 2 organization and enjoyment, and component 3 ICT support for learning.

The content of the items that have high loadings from each factor were examined to see if they fit together conceptually and named. Factor loading is the correlation coefficient of an original variable with a factor. In Table 11, factor loadings below 0.5 were suppressed, so that only the higher loadings appear for easier extraction of factors.

For mathematics, Factor 1 included items 4, 5 and 8, related to the organization of the class, effect of computer use on students understanding, and their achievement. Factor 2 included items 3 and 6, representing easiness of learning and perceiving mathematics activities using the computer as fun and interesting. Finally, Factor 3 included three items related to students' feelings about the use of ICT, including enjoying the Math class, feeling of nervousness, and having prior knowledge of what is expected to be done.

For science, Factor 1 was composed of items 2 and 4, related to ability of the student to achieve better marks with no feeling of being nervous. Factor 2 included items 1, 3, and 8, which were related to enjoying the science class as being fun and organized. Factor 3 included items 5, 6, and 7, which reflected the easiness of using computer in the science class.

*Table 11: Rotated Component Matrix*

| Attitude Items | Mathematics Component | | | Science Component | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 |
| 1. I enjoy the Maths/Science class when it is the computer lab. | | | .752 | | -.719 | |
| 2. The use of Computers in the Maths/Science class doesn't make me nervous. | | | .729 | .736 | | |
| 3. The activities in the Maths/Science lesson on the computer are fun and interesting. | | .816 | | | .696 | |
| 4. I can achieve better marks when learning Maths/Science on the computer. | -.663 | | | .884 | | |
| 5. The use of computers makes me understand more the Maths/Science Subject. | .791 | | | | | -.557 |
| 6. It is easier to learn from using computer than from the Maths/Science book. | | .874 | | | | .806 |
| 7. I know what I am expected to do with the computer in the Maths/Science class. | | | .721 | | | -.607 |
| 8. The Maths/Science class in the computer lab is well organized. | .914 | | | | .621 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Initial Eigenvalue | 2.944 | 1.608 | 1.478 | 2.393 | 1.593 | 1.213 |
| Total Variance (Math = 75.372%, Science = 64.987%) | 32.161 | 21.849 | 21.363 | 24.331 | 21.429 | 19.226 |
| Reliability Coefficient (Cronbach's Alpha) | 0.732 | 0.670 | 0.577 | 0.808 | 0.557 | 0.407 |

A popular method for measuring the internal consistency reliability of a group of items is the Cronbach's alpha coefficient. Cronbach's alpha measures how well a set of variables or items measures a single, unidimensional latent construct. Running reliability analysis in SPSS for the extracted factors in Table 11, Cronbach's alpha was calculated and reported at the bottom of the table for each extracted factor. Cronbach's alpha values range from 0 to 1, and, in the social sciences, values at or above 0.7 are desirable, but values well above 0.9 may not be desirable as the scale is likely to be too narrow in focus (Henson 2001)

From the values of Cronbach's alpha reported in Table 11, it can be seen that Factor 1 in both subjects was the most reliable as it had a Cronbach's alpha of 0.732 and 0.808 for mathematics and science, respectively. The value of Cronbach's alpha for Factor 1 is considered reliable as the acceptance value is, where the value of alpha > 0.6. Cronbach's alpha is acceptable for Factor 2 in mathematics. Factor 2 in science, Factor 3 in mathematics, and Factor 3 in science had low Cronbach's alpha, indicating poor reliability. However, the current study used a questionnaire with few number of questions and a small sample size. Increasing the number of questions to the test can increase the alpha value. So, results of reliability analysis should be used with caution (Henson 2001).