Chapter ONE

INTRODUCTION

1.1 Overview

Laptops, mobiles and tablets like iPads, are being used to educate and engage children around the world since the last decade. Buckingham (2007) confirms this, with statistics from the UK government, that there has been a noteworthy increase of hardware in schools during this time. This development in education has greatly affected the thinking and learning of the younger generation, as well as their exposures, thereby rendering them with the uncanny ability to learn its use with ease (Papert 1996). As a consequence of their association with technology, children have become not only consumers of knowledge, but also producers (Buckingham 2007). It has been acknowledged that technologies carry powerful ideas and due to this trait, have become a driving force in education (Beals & Bers 2006). Edwards-Leis (2007, cited in Castledine & Chalmers 2011) claims that for students to understand, and thereby, associate and convey their knowledge to real life problems encountered every day, they must genuinely connect the 'how' and 'what' of their learning. Papert's (1980, 1993) Constructionist theory suggests that children, while actively building on their intellect, construct their meta-cognitive skills. He also indicates, by mastering the use of computers and software, students transfer their learning to real life situations, especially in the realm of problem solving.

Figure 1(source: http://mindstorms.lego.com)

Children have always been known to be engaged with hands-on material but in this world of ever changing technology, if these materials were fun and creative, then learning can only get better (Figure 1). Digital manipulatives such as robots can enhance the conventional hands-on materials by providing students with oppurtunities to explore the concepts beyond what traditional materials, like textbook and lecture-notes, could afford. Rusk et al (2008) define robotics as all kinds of programmable devices that do actions depending upon inputs from sensors. Robotics can be used to teach concepts to students struggling with textbooks and traditional form of instruction as it combines creativity and engineering (Maud 2008). Students' familiarity with robots, allows their relating them with sophisticated, yet accessible ideas; and their interest is captured as they are intrigued by them (Parsons & Sklar 2004). In their study, Rogers and Portsmore (2004) introduced a curriculum for robotics lessons that first, teach students to be inquisitive and creative and then make available engineering means and skills to satisfy their own curiousity. They noted that, in addition to being exciting, robots make possible for students to create trial products and test immediately.

Robots can function as the perfect tool to teach children about Science, Technology, Engineering, and Math (STEM) concepts, in enjoyable and artistic ways which are otherwise taught using dull and uninspiring methods, like lectures and notes (Beals & Bers 2006). The use of robots in these collaborative disciplines presents a potent and open platform to explain a range of engineering topics (Skelton et al 2010). Teaching with robots is in line with the twenty-first century education goals in that, it enables students to engage in collaborative activities and accomplish more tasks than what can be achieved individually (Ebomoyi & Easter 2010). Moreover when students learn how to design a complete system that functions in the real world they acquire problem solving skills that would benefit their future careers, irrespective of the discipline they opt for (Beer, Chiel & Drushel 1999).

Figure 2 (sources: www.movieline.com;www.ros.org;www.bbc.co.uk;www.inhabitots.com;wwwpicstopin.com)

Previously, robots were seen only in movies and industries, with children always looking upon them as dangerous machines, causing harm (Figure 2). Presently, they have arrived at the doorstep of education offering learning with joy, to these very same children. LEGO has developed robotic kits that allow students to explore abstract ideas and designs with concrete objects. The idea that learning by doing and creating artefacts is central to the LEGO philosophy since conception (Figure 3).

Figure 3 (source: www.legoeducation.com)

This idea is also fundamental to Papert's Constructionist theory (Dennett 1993). Robots for classrooms can be bought on a limited budget and also children as young as 9 -11 years can construct them and calibrate the sensors making them good concrete examples (Parsons & Sklar 2004). Maud (2008) stated that robotics in learning, lends itself remarkably well to a class where the aim or the product is made clear; and the methods to achieve it are left to the students. They can choose their own path, move at their own speed while trying unique, odd and amazing approaches within self set limits, which may even surprise the teachers. Maud, in his study, added that, in robotics, situations can be generated such that students work in groups to create a product, resulting in them working closely with its members and those of other groups, in order to arrive at that final outcome. Beer, Chiel and Drushel (1999) identify teamwork as an important skill that robotics happens to cultivate. Thus students can collaborate, do trial and error, collate information, evaluate and modify methods as they work together.

In their study, Rusk et al (2008) attributed the educational appeal of robotic activities to its physical (with materials, gears, sensors and motors) and computational design (program the actions of the robot) adding that students learn Engineering, Maths and Computer Science concepts in the process. Understanding, aptitude and learning techniques that are not employed or even valued in conventional classrooms, may be brought into play in robotics classes with designing, constructing and programming (Rogers & Portsmore 2004). Here, in-depth learning occurs rather than just the taking-in of information. However, while there has been research studies (Pike 2003; Skelton et al 2010) that suggest robotics entail collaborative, creative and authentic learning experiences, a number of studies that examined 'learning achievement' in terms of academic scores found that robotics did not help significantly to improve students' academic scores (Fagin & Merkle 2003). The reason for the decline in students' scores was found to be not the actual use of robotics in class to teach but the manner in which the Lego robotic lessons were implemented. Clearly it can be noted that "while robots have positive potential, they are no panacea" (Barker & Ansorge, pg.232).

1.2 Statement of the Problem

The UK Education secretary (Department of Education 2012) announced his decision to change the ICT GCSE curriculum from the teaching of ICT skills to that of programming. It was to be designed with the help of universities and the industry; and implemented the next academic year. This decision was welcomed by many, stating that ICT skills can be learnt by the students themselves in very little time, leaving them bored (Burns 2012) while the learning of programming entails many other useful life skills such as critical thinking, problem solving, team work and collaboration. In *BBC News* (11 January 2012) some teachers commented that the students would enjoy the interaction in programming and the logical aspect would help in their thinking; while some were concerned with the lack of programming skills in the existing teachers, the piecemeal changes leading to ineffective implementation and the abilities of below average students to cope. Issues regarding costs, infrastructure and assessment were also brought up. Others opposed this change stating that the existing curriculum that teach presentation and excel are necessary skills in the workforce and the new policy has no clear approach or time frame or even ideas on how to teach it (Curtis 2012). Previous studies (Rogers & Portsmore 2004) claimed that it is vital to make students at ease with technology before they enter university and letting them experience designing, constructing and programming in K-12 is a good means to achieve this. Unfortunately most students find problem solving and programming concepts complicated and cannot relate the abstract skills to real life problems (Oddie et al 2010). Cuban (2001) asserts that particularly with young children, introduction of new technologies in schools encounter great difficulties. However, most of the problems are not due to the technology itself, instead because of the poor logistics with respect to lack of continuous time and a poor teacher-student ratio of one to 20 (Rogers & Portsmore 2004; Beals & Bers 2006). It is interesting to note similar debates in previous studies where on one hand, some secondary schools preferred to stop programming completely in favour of computer literacy courses (Goldenson 1996) and on the other hand, some strongly believed that programming is a necessary skill to learn before getting into any profession or even for the sake of general education (Soloway 1986).

In order to understand these debates, it becomes important to look at the perceptions of those who are dealing with it directly i.e., students and teachers. Due to its strong influence on well being and behaviour, perceptions are vital in education as in all other areas of human activity. The academic achievement of students can be affected by their perceptions of learning experiences like student-teacher interactions, teacher expectations, and school events (Siegle & Reis n.d.). It is very important to address the perceptions of those directly involved, such as the teachers and the students, to assess the quality of any educational implementation as sometimes perceptions may contradict what seems to be the actual situation. Ahmed and Aziz (2009) claimed that when individuals are given the opportunity to be heard, their awareness regarding their own learning experience or teaching practice is aroused. Wittrock (1986, cited in Ahmed & Aziz 2009) declared that teachers and students can use studies conducted on their own perceptions to reflect upon their teaching and learning, in order to improve their understanding and outcome. The attitudes of teachers and students are often ignored in studies that seek to evaluate the effectiveness of technology implementations (Harper, 1987; Clarke, 1983 cited in Albirini 2006) even though they are the most important stakeholders in the teaching and learning process. **Therefore the purpose of this research study is to explore the perceptions of students on two levels, Primary and Secondary; and the teachers, who teach the subject to these levels.** A pilot study had been conducted earlier on middle school students with interesting results which will be discussed in the Literature Review chapter.

1.3 Background of the Research

Engineering is an effective means to teach, learn and extend education, but not a discipline one would expect to find in elementary or secondary levels at schools (Rogers & Portsmore 2004). With respect to primary students, robots have been validated as useful teaching aids in Maths and Physics as they capture their imagination (Cooper et al 1999 in Chang et al 2010). Matson, DeLoach and Pauly (2004) declared that while robots are a subject of universal interest for children of all age groups, the scientific interest peaks for those at the K-6 age range. They also noted that giving children such opportunities will not only interest them but also inspire them to pursue engineering and science studies in the future. Their study noticed the logical manipulation of robots by these young children and they further studied the logical and critical thinking skills of children as they believed that solving logical problems will help the brain develop the required neural plasticity to be able to think logically and solve problems during its lifetime. Rogers and Portsmore (2004) could not agree more as they discovered that elementary students had the capacity to learn Physics, programming and Maths concepts much sooner than expected when offered in the form of engineering tasks which appealed to them since they include creative as well as practical work. However, Palumbo (1990) questioned the prerequisite skills these young children may possess to learn the programming language or the ability to transfer the programming skills to other problem solving realms. But Lawhead et al (2003 cited in Oddie et al 2010) clarified stating that using robots to teach entry level programming is beneficial as it focuses on learning language-independent yet permanent facts of programming and its techniques, adding that robots offer a concrete model to visually explain concepts. **Keeping in mind these arguments, this study seeks to shed light on the attitudes and beliefs of primary school students regarding learning to program with robots.**

A country's future competency and security is dependent on its talented human resource in fields of Science and Engineering (Hendricks, Alemdar & Ogletree 2012). In *The National* (11 June 2010) it was stated that the number of students opting for majors in Science, Technology and Engineering in the UAE are significantly less compared to the needs of the labour market. Studies (Rockland et al 2010) conveyed that the case is similar in the U.S. where many students are not interested in these fields and therefore, not opting for STEM careers. This has resulted in educators looking for new and significant means to attract students to Science and boost their attitude towards Technology (Cavas et al 2012). Recently, government officials in the U.S. have been raising issues on technology in schools. In *ABC News* (12 February 2013, pg.6), President Obama announced, in his State of the Union address, that he wants to redesign schools to meet ''the demands of a high tech economy". The latest advice (Office of the Mayor 2013) comes from the New York Mayor who declared the 20 school pilot programming program starting this fall. Robotics is a multi-disciplinary field which makes it perfect to involve practical application of mechanical engineering, electrical engineering, computer engineering, and computer science concepts into the school curriculum. Skelton et al (2010) discovered in their study that exposing secondary school students to robotics made them interested and enthusiastic about taking up engineering studies, in addition to improvement in their self esteem and presentation skills. Robotics presents a fresh and stimulating way to attract and inspire secondary school students to take up these disciplines in the future. In addition to exposing students to new career choices, the high ceiling of the robotics kits allows for difficulty levels further than the abilities of high school students, thereby providing for extended activities (Rogers & Portsmore 2004). Another study (Lenschow 1998) pointed out that a concept of lifelong learning is developed by creating an environment using robots to learn engineering at the pre-graduate level. In addition, engineering educators are concerned with the lack of prerequisite knowledge of the students who do join the courses, thereby emphasising the need for technology as a school subject, where they learn science and technology through design, construction and operation of systems (Verner, Waks & Kohlberg 1999). There are some studies, however, that claim that students didn't find it as useful as lectures or homework but more helpful than the textbooks (Parsons & Sklar 2004). **This study aims to explore the perceptions of secondary school students who opted to study the subject to participate in competitions, regarding robotics in schools and their interest in the STEM fields.**

In addition, **this study aims to consider teacher beliefs and attitudes as they play a vital role in the implementation of robotics in schools.** Hopson, Simms and Knezek (2002 cited in Cocek 2008) asserted that students in the digital age must learn, in addition to accessing data, to manage, analyse, critique, cross reference and transform it into useful information; and while the development of these skills are vital for their future success, their acquirement is quite a challenge for the 21st century educators. In order to encourage critical thinking skills, teachers must be able to create environments that engage the students with well designed problems, involving them in collaborative work, with ample practice time (Cocek 2008).Their teaching patterns are highly influenced by their specific aims, and their teaching beliefs affect their implementation of pedagogy and students working style (Norton, McRobbie & Ginns 2007). The teachers must plan their lessons keeping in mind students' needs and interests; and their enthusiasm is generally demonstrated in their actions and decisions in the class, whereby they cultivate the interest in their students. Their passion for the subject which, when expressed through their teaching styles, can greatly influence students' perceptions. Needless to say, a well organised teaching plan along with a favourable learning environment renders students comfortable, in spite of the subject complexity and ensures that, they not only learn, but also like the subject.

A technology enhanced learning environment is expected to promote dynamic and innovative independent learning, by creating oppurtunities like collaboration and virtual problem-solving in authentic contexts, that is impossible in traditional settings such as a classroom with only the teacher imparting knowledge (Ng & Gunstone 2002).Teachers must be able to create, engage and stimulate the critical thought process by looking into the new tools and pedagogy that are developing in their current version of technology (Cocek 2008).Teachers of robotics are faced with specific challenges as students have to deal with the complexity of subject content, as well as creativity. To be able to instruct students in a very active robotics classroom, it is imperative that the teachers possess competencies in robotics instruction, in addition to design and analysis of mechanical and electronic systems (Korschnoy & Verner 2010). Studies (Castledine & Chalmers 2011) have established that correlating LEGO with problem solving involves cautious teacher scaffolding where they work as facilitators. Scaffolding (Vygotsky 1978) is an effective way to develop skills and strategies with assistance from the teacher or peer-interactions, until the student, who is at the Zone of Proximal Development (ZPD), masters the task and can complete the task on his own. As the teachers' roles change from being instructors to facilitators when they use this powerful tool in their classrooms to teach programming, it is very necessary to understand their perceptions.

The following section clearly states the research questions that directed the study.

1.4 The Research Questions

With Papert's constructionist theory eventually resulting in the development of LOGO programming into LEGO Mindstorms and the change in the UK (GCSE) ICT curriculum, it is essential that schools take notice of robots knocking at the doors of education and work towards the successful implementation of the same. Bearing in mind the significance of metacognition in learning and in learning to program, educators must decide on the best practices to integrate robotic programming into the curriculum. The importance of perceptions and their impact on performance and learning is yet another indication of setting an ideal environment to promote maximum learning. With all these considerations, this research aims to find answers to the following research questions:

1. **How do primary students perceive using robots to learn programming?**

2. **How do secondary schools students perceive robotics to get introduced to engineering and programming careers?**

3. **How do teachers perceive using robots as an educational tool to teach programming?**

1.4 Significance of Study

The World Robotics Olympiad (WRO) 2011 was held in Abu Dhabi and a number of schools from all around UAE had participated and competed against schools from different parts of the world. Private and public schools in the UAE are planning to follow the UK curriculum changes and add programming in the form of robotics. Much research has been conducted previously regarding the use of robots as a teaching tool and its potential to aid students learn problem-solving (Palumbo 1990) and develop interest in science and mathematics including gear mechanics and motion (Chambers, Carbonaro & Murray 2008) and ratio (Norton, McRobbie & Ginns 2007). This research, however, builds on these prior studies but specifically focuses on the perceptions of the UAE based students and teachers regarding the use of robots in their schools to learn and teach programming respectively. It is essential to provide these students with learning environments to enhance their technological literacy and critical thinking skills beyond the classroom that is necessary for modern times (Castledine and Chalmers 2011).The results of this study may reveal several aspects that may assist in developing strategies for the successful implementation of the new curriculum. Policy makers and IT administrators may find relevant information in the perceptions of students and teachers. Curriculum advisors may use these perceptions to design the new course to fit these tools into the current ICT curriculum. Last but most importantly, teachers may use this information to successfully implement the new curriculum in the classrooms.

The Organisation of the Research

This thesis is organized into 7 chapters. This chapter provided the background to the research on the use of robots to learn programming as well as the significance of studying the perceptions of students and teachers in education. The next chapter will review relevant literature pertaining to Papert's Constructionist theory and the development of LOGO programming language to LEGO and its features. The literature relating meta-cognition to learning and in particular to, learning programming will also be reviewed. In addition, literature looking at the significance of perceptions in education will be discussed followed by the pilot study previously conducted in middle school regarding the same subject. Chapter three will speak of the methodology used in this study including the participants, data collection techniques and analysis of the data. The following chapter will report the results of the study with charts and tables. In Chapter five, a discussion of the results will be presented. Chapter six will share the limitations of the study as well as the recommendations that developed from the study and Chapter seven will conclude the study.

CHAPTER TWO

LITERATURE REVIEW

The specific focus of the review of literature will be an examination of Paperts' constructionist theory and its role in robotics; the use of LEGO Mindstorms kit as the digital manipulative; the connections between meta-cognition and learning to program; the significance of perceptions in education; and the pilot study already conducted in the middle school. These issues embrace the subject matter for the review of relevant literature and strengthen the theoretical framework by which this study was guided.

2.1 Papert's Constructionism

Seymour Papert (1980, 1993), a Lego professor of Learning Research in Massachussetts Institute of Technology (MIT) and a protégée of Jean Piaget, uses Piaget's belief of Constructivism to connect technology and learning. He developed a programming language LOGO to improve the mathematic skills of children. Constructivism is a child-centered theory of education where the child actively processes meaning and learning; proceeds at its own pace with no deliberate teaching or prescribed curriculum; and the teacher is nothing but a facilitator (Buckingham 2007). Vygotsky (1962) stated that the basic principle of Constructivism is that learners participate dynamically in constructing knowledge which is influenced by the existing knowledge as well as the socially interactive environment. Papert formulated Constructionism, which is a method of education based on Constructivism, that involves learning by 'doing', taking into account their prior knowledge and experiences (Ng & Gunstone 2002).The constructionist theory argues that when children work with materials that allow them to design and build meaningful artefacts, then they learn better (Rogers & Portsmore 2004). Papert claimed that children are the designers as well as producers of their own knowledge when they control their own learning, keeping in mind their own knowledge as well as that of intended users (Kafai 1995). Hands-on experiences allow the learners to 'assimilate' new skills into their existing knowledge and when these new experiences do not fit into their thinking structure, they 'adjust' their thoughts (Cocek 2008). Papert's (Dennett 1993) claims were based on children that interacted with the LOGO interface in an informal manner and he insisted that the anecdotal accounts of these interactions were convincing enough to influence research on information technology and learning (Ng & Gunstone 2002). His studies with these children led him to the concept of Constructionism which opposes the traditional method of Instructionism, where students remain passive listeners. Papert (1991) made a case that if children are constructing an object that others will see, use and criticize, then, they will be more involved in the learning that occurs. Kafai (1995) upholded this case stating that children control their learning as they bring in their own knowledge and connect with the ideas of the users to create artefacts with questioning, gathering data and problem solving. Yet another study (Bers et al 2002) elucidated that teaching with robots is appropriate for early childhood education, as it fulfils the basic beliefs of Constructionism, where children are learning to design meaningful artefacts using concrete objects with personally powerful ideas while engaging in self-reflection. However, Dennett (1993) asserted that most teachers using LOGO in classes came up with mixed results. He agreed from personal experience that LOGO does work miracles in right conditions, but these conditions are difficult to create. Buckingham (2007) deduced that the major promise of LOGO weakened due to students' difficulties. He argued that Papert's studies were based on his own set of assumptions about learning, childhood and his findings on children learning LOGO, which cannot be generalized into broader arguments.

As for problem solving, Palumbo (1990) claimed that traditional educational methods such as lectures and textbooks did not help much to facilitate transfer of concepts. Papert (1991) agreed adding that integrating technology into the realm of problem solving can establish real-world problem solving skills in children. A study by Castledine and Chalmers (2011) however made evident that while this is true, the learning experiences must be scaffolded cautiously so that the students may relate their problem solving understanding to authentic settings. Also another study (Norton, McRobbie & Ginns 2003) demonstrated that problem solving activities as well as the Science and Maths appreciation related to the construction and mechanical operation of the robots were greatly overshadowed by the programming aspect of the robots. They claim that the teachers found it difficult to make connections between the robot's technological movements and the subject goals, thereby rendering the principles implicit. The universally claimed problem solving transfer that promoters of programming hoped to achieve did not happen in a year-long study that showed programming had no effects on achievement except for progress with age or with practice on the designing tasks (Pea, 1984 cited in Palumbo 1990). Papert, however, did not believe that any test could bring to light the benefits that he reported. He believed these tests wreck the very learning environment that computers can give rise to (Dennett 1993). Without any specifications, he suggested the need for a good feedback system for this to work, in addition to a radical change in the whole system of schooling. Thus, the argument regarding the use of programming in education raises many questions.

The LOGO programming team worked in conjunction with MIT and LEGO, the plastic building blocks company, to create the LEGO® MINDSTORMS® NXT product, an innovative and enjoyable trend in education (Dennett 1993). This trend strengthens the call by National Science Education Standards (NRC 1996) to actively engage the students with designing, constructing, analyzing and problem solving, thereby rendering them capable of addressing applications outside classrooms. These NXT robots fit well with the constructionist theory of learning as they make available an active constructionist setting where students are building tangible objects and coming into contact with abstract concepts in meaningful ways (Chambers, Carbonaro & Murray 2008). The following section looks in detail into the development of the product.

2.2 Learning with LEGO® MINDSTORMS® NXT kits

Papert (Barker & Ansorge 2007) alleged that the constructivist theory is best practised with robots as it speaks about experiential and problem-based learning where students learn concepts through genuine problems in small groups with teachers as facilitators. The flexibility and power of programmable robots make possible the demonstration of concepts that had no real-world comparisons in the past. The motivation and thrill inspired by the LEGO kits provide excellent learning foundations in many disciplines across the curriculum (Roger & Portsmore 2004). In addition, its low entry level and high ceiling enable students to develop and work with it for several years thus increasing learning time and reducing time engaged in being taught new tools.

LEGO collaborated with MIT in 1984 to bring into being, programmable teaching toys possessing advanced technologies (Chang et al 2010). These instructional toys called LEGO® MINDSTORMS® NXT kits can be used by students to design, construct and program robots and learn during the process. As they are reasonably priced and reusable, in addition to providing increased motivation and excitement in students, they are considered acceptable educational tools to improve skills in Mathematics, Science, programming, Engineering and collaboration; in K-12 and undergraduate levels (Skelton et al 2010). Some studies (Kanda & Ishiguro 2005 cited in Chang et al 2010) highlight that while robots in classrooms do motivate students quickly and notably, it can be rarely maintained. Then again, with these kits, students can explore conventional everyday items such as gears, levers, motors, joints and sensors integrating creativity and individuality in meaningful projects (Beals & Bers 2006). They actively engage students in constructionist learning environments, thus encouraging higher order thinking skills and supporting conceptualisation in relevant and genuine ways (Chambers, Carbanaro & Murray 2008).

LEGO® Education endorses its LEGO® MINDSTORMS® NXT Robotic kits declaring that students are in a state of flow when they are learning with them (LEGO 2006). Csikszentmihalyi (2000) described the state of flow as one with dynamic equilibrium, which is experienced when there is a delicate balance between perceived ability and perceived oppurtunity. If challenges go beyond skill level, learner first becomes alert then uneasy and if skills surpass the challenges learner first relaxes then becomes uninterested. He identified conditions for flow as when the perceived challenges match existing skills or when the challenges are apt for ones abilities and also the goals are proximal with immediate feedback about progress. In other words, the learner is experiencing attainable challenges while continuously processing feedback on progress and modifying actions according to this response. This experience just progresses effortlessly and the learner is fully engrossed in the activity with action and consciousness fused and completely in control of one's actions with complete distortion of time and place.

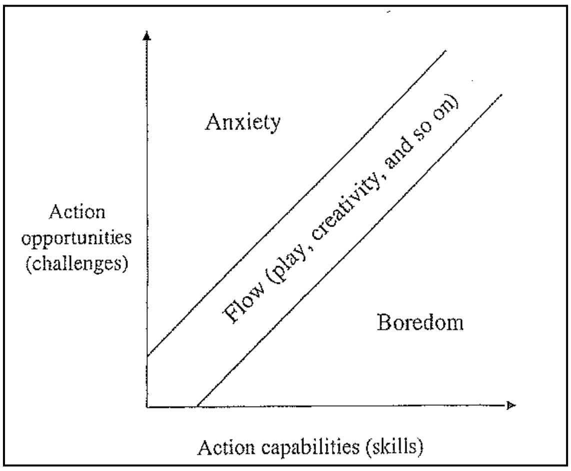
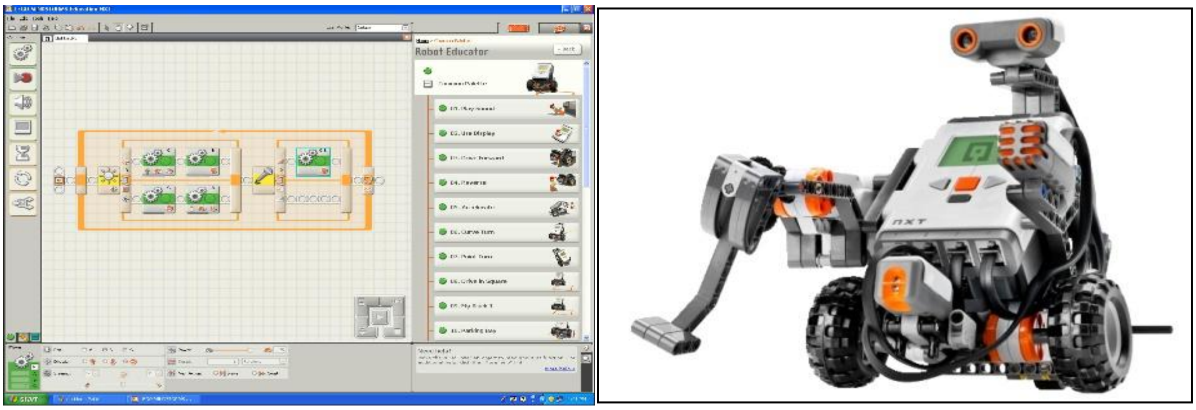


Figure 4 (source: Nakamura and Csikszentmihalyi, 2002)

Nakamura and Csikszentmihalyi (2002) had mapped three areas of experience (Figure 4) in terms of challenges and skills. The flow channel is where the challenges and skills coordinate. The area where oppurtunities with respect to skills drop, represents the boredom area and the anxiety region is where the challenges go beyond the capacities.

Moving onto its physical properties, a LEGO® MINDSTORMS® NXT robot has a programmable brick which has a 32-bit microprocessor, a matrix display with 4 input and 3 output ports. The NXT brick has a fixed memory of 256 Kbytes of which 125 Kbytes is used for firmware (www.legoeducation.com). The basic kit comes with three motors, a light sensor, a touch sensor, a sound sensor and an ultrasonic sensor. Wheels, gears, cables and connectors are also included. The LEGO® MINDSTORMS® NXT software, compatible with PC and MAC, allows students to program and using USB or Bluetooth connectivity, the programs can be uploaded onto the NXT robots. The kit comes with guides enabling students to effortlessly start building and programming (www.legoeducation.com). Many studies have provided evidence that when programming is taught with visual depictions, students respond better than text based instructions (Oddie et al, 2010). Likewise, the NXT software uses a drag and drop graphical interface with many levels of difficulty, entitling the users to tailor its functions based on their personal skills (Figure 5a). This is useful as students need not worry about programming language grammar or syntax and reinforces logical thinking as the robots work unexpectedly only if logical errors existed.



a b

Figure 5 (source: mindstorms.lego.com)

Mosley and Kline (2003) claimed that robotic kits can engage all students with core tasks while providing oppurtunities to advanced students to work on extended activities. They allow visual feedback, with experimentation using the sensors and exploration with modifications due to environmental reasons such as, surface friction or sensors being affected due to light. They provide real world situations to learn programming concepts and its vocabulary in an appealing way. The unique experience, the low cost with the plug and play feel contribute greatly to these kits supporting education successfully (Weinberg & Yu 2003 cited in Chang et al 2010). Additional products are available from the same company with stackable blocks of many sizes, shapes and colours to enable children to create beyond imagination (Figure 5b).

2.3 Meta-cognition and Learning

Meta-cognition is vital in learning (Schraw 1998; Hull & Boulay 2009) as it facilitates better management of cognitive skills and allows discovering of weaknesses which can be rectified with construction of new cognitive skills. Paul (1990, p. 57 cited in Cocek 2008) is in complete agreement when he said that "Developing the habit of reflecting on the logic of what one learns is key to critical thinking". According to Papert's (1991) constructionist theory, students construct meta-cognitive skills themselves as they build their own intellect actively. Pang (2010) iterated that for successful authentic learning, it is essential that students understand the meta-cognitive and the reflective practices they use. Reflection is vital in robotics as it enables students to realize their weaknesses, their strengths and also view the problems from various angles, which in turn guides their logic, to figure out the next steps in the process (Cocek 2008).Furthermore, it provides a strong link between thought and action as it contributes to information regarding outcomes and the success of used approaches and thereby, allows the students to consider strategies preceding the tasks, as well as assess and modify during the process (Castledine & Chalmers 2011).

Schraw (1998) identified that meta-cognition has two major components namely knowledge of cognition and regulation of cognition. The former refers to one's awareness about own cognition and the latter indicates the actions one takes to control one's learning which, improves one's performance with better attention, better use of known strategies and breaking down comprehension with awareness. With respect to knowledge of cognition, he claimed that it includes three different kinds of awareness: declarative which is knowing 'what' one knows, procedural that is knowing 'how' to do things and conditional which is knowing 'why' and 'when' to use declarative and procedural knowledge. When students visualize the connections in the process, it strengthens and expands their conceptual knowledge and connections to prior knowledge encourage long-term memory and transfer between subjects (Cocek 2008). Studies (Barker & Ansorge 2007) have found that students who are encouraged to transfer the taught procedural knowledge to related and unrelated situations become responsible for their own understanding, look to further their knowledge and have the ability to generalize their learning. This results in improved long term retention, enhanced motivation and progress in problem solving, in addition to social development. Students can actively be involved in constructing their knowledge if they focus on self-appraisal and self management thereby, conceptualizing their learning (Carbone et al n.d.)

Schraw (1998) in his work mentioned studies that report improvement in learning when classroom instruction includes teaching of regulatory skills and understanding its use. Cocek

(2008) suggested that meta-cognitive skills can be taught at elementary level in schools. He added that robots in classrooms seem to be an ideal tool to encourage meta-cognition as when students solve problems together as groups, peer interaction renders them to actively engage in their learning and well-structured collaborative activities allow students time to question, develop new ideas and assess peer comments and ideas. Teaching students to be meta-cognitive is a difficult task but Pang (2010) stated that it is possible, when carefully scaffolded by the teachers. Schraw (1998) indicated in his work three vital skills, namely planning, monitoring and evaluation that should be taken into account when attempting to teach meta-cognition. Planning includes selecting of apt strategies and allocating of resources such as sequencing of the strategies or allocating time or attention before the task itself. Monitoring, on the other hand, involves one's awareness during task performance with self-testing while learning; and evaluation refers to appraisal of one's products and learning efficiency, such as goals and conclusions. He emphasized that crucial to construction of meta-cognitive knowledge and improvement of regulatory skills, is extensive practice and reflection. This again can be possible with robots in the classrooms.

2.4 Meta-cognition and Programming

Programming can be defined as the solution to a specific problem, where the problem must first be understood and analysed and finally, the solution algorithm is translated into the code (Oddie et al 2010). The primary feature of cognitive processing involved in problem solving is the representation of the problem (Palumbo 1990). Programming goals include two kinds of knowledge, namely declarative knowledge, which is learning the command structure of a particular language; and procedural knowledge, which is the ability to use the declarative knowledge in tactical ways in different situations (Palumbo 1990). However, it must be noted that even though transfer is the main reason publicized for teaching programming, empirical evidence is mixed (Goldenson 1996). Buckingham (2007) agreed that there is very limited evidence showing transfer of procedural thinking skills. Goldenson (1996) stated that well executed entry level programming lessons may develop, at the least, efficient attention to details and high level design skills.

Meta-cognition in programming includes meta-components, such as understanding the nature of the task, then planning the necessary strategy to solve the problems, sequencing the steps, choosing a representation and finally, monitoring the progress of the solution. Clements and Nastasi (1999) noted in their study that the application of reasoning skills to academic tasks, in relation to these processes is found to occur repeatedly in environments that encourage high level thinking. They also identified that while some meta-components improved, others had limited impact. However, Carbone et al (n.d.) had drawn attention to much data collected which stated that generally, students do not reflect or even understand what they do and are mostly deficient of tactics to improve their learning. They pointed out that the nature of challenges in programming emphasized this, as students lacked the ability to transfer learning from other subjects and the high demands of coding created cognitive overload for them and they usually overlooked the logical aspects. Goldenson (1996) added that programming cannot ensure that the curriculum and educators will concentrate undoubtedly on problem solving skills as programming languages are just tools. Another study (Hull & Du Boulay 2009) indicated that learners considered programming as a difficult skill as they were not given enough instructions to put together the different programming elements to develop a program solution. The study added that this difficulty affects one's motivation and meta-cognitive processes. Carbone et al (n.d.) in their study pointed out that, students did however, identify own thoughts and the lack of the same in others. In addition they realised that missing out on any lesson rendered them incapable of understanding following lessons. On another level, students believed that a step by step instruction strategy left them with raising no questions, resulting in no learning.

Reflection, previous experience and knowledge are meta-cognitive behaviours that play a vital role in problem solving, thereby programming (Hull & Du Boulay 2009). Research (Carbone et al n. d.) informed that tasks where students can reflect, discuss and analyse own learning, influence their meta-cognition. Clements and Nastasi (1999) agreed that explicit discussion of the meta-components mentioned earlier may stimulate meta-cognition in students, by creating a learning environment with debugging models that encourage students to discover and rectify errors with teachers bringing out student's cognitive monitoring with appropriate questioning. Students can first learn simple concepts of the components which they eventually use to solve problems and finally use it automatically. Traditionally students were taught to identify and understand the syntax and structure of the programming language then use them with methods and knowledge of well-thought out problem solving (Oddie et al 2010). In modern times however, robotics can enable programs to be understood better graphically and also students can, not only touch but also see their logic result instantly (Goldenson 1996). Thus, programming connects structure with abstraction. Students must be able to see these technologies as tools in a learning context seeking deeper perception by connecting the different aspects (Cope & Ward 2002). The next section addresses the significance of students' and teachers' perceptions in education.

2.5 Importance of Perceptions of Students and Teachers in Education

Students' perceptions, teachers' perceptions, teachers' perceptions of students' perceptions; all play a key role in learning. Research done by Cope and Ward (2002) regarding teachers' perceptions on technology integration in classrooms confirmed successful integration is related significantly to them. Their approaches as well as the environments they create make an impact on students' perceptions. Consequently, students' perceptions in terms of learning and motivation constructs, have great effect on school improvement and student achievement (Gentry & Owen 2004). Parr (1999 cited in Cope & Ward 2002) discovered that successful integration with respect to ways and amount of technology use; and teachers' and students' learning expectations, was highly influenced by students' perceptions. Bandura (1994) stated that students' accomplishments are greatly determined by the way they perceive their abilities and he emphasised that their perceptions defined what they considered achievable goals. In his earlier study (Bandura 1977), he had made a case claiming that learning environments, rich in encouragement and motivation with peer interactions, repeated successes and supportive risk taking, positively impact student self confidence, behaviours and attitudes toward learning. Cope and Ward (2002) claimed that only when teachers perceive and employ technology with a student centred approach to teaching, successful integration of the same is possible. Similarly when students perceive learning to be independent with in-depth learning approaches, enhanced learning effects can be expected. As teachers need to provide for differences in students, a better understanding of the teaching process and learning outcomes will be obtained from research on students' thinking as experienced by them (Ahmed & Aziz 2009). In other words, teachers can evaluate the consequence of their teaching techniques by identifying them from the student's perspective.

Students' perceptions are influenced by the stimulating and motivating experiences in the classrooms where they interact closely with the teaching and learning ways, being conscious of their own learning as well as the teaching process (Ahmed & Aziz 2009). Motivation, values and attitudes are three main things that influence perceptions in individuals. Ambrose (2007) claimed that for the complete picture of competency in learning, meta-cognitive factors namely, thoughts, understanding, emotions and intentions must be included, as these impact behaviours such that they even influence different results of performance in students possessing same skill sets. Mayer (1988 cited in Jonassen 2000) claimed that students, when motivated, use higher level thinking as they believe they can successfully solve the problems. Schraw (1998) added that promising students have greater self efficacy feelings and they believe their success is due to their effort and planning and when faced with challenging situations they persist to find solutions. On the other hand, students who believe they lack in academic ability make no extra effort to excel in a task. Bandura (1977) asserted that self efficacy is not concerned with one's skills but rather with one's judgement of what one can do with whatever skills one has. It is safe to say then that students' self efficacy beliefs strongly motivate their learning experiences. Interest in the subject (Pichler & Gasparikova 1999) and taking the subject seriously (Shulman 1999) are two other aspects that play an important role in the successful learning. Hull and Du Boulay (2009) have established that motivation is key to learning and motivated students enjoy more success and show better self regulation, which results in further motivation. However, Buckingham (2007) claimed that motivation may be only temporary and superficial.

Therefore, in relation to this study, an ideal robotics classroom must have students achieve individual goals with self planning and recognizing own abilities by comparison (Maud, 2009). Also, readiness to help and collaboration with group members and other groups greatly enhance the robotic class experience (Korcshnoy & Verner 2010). In other words, students must be involved in the process and develop an understanding of the concepts without even realizing as the environment created makes them want to gain the knowledge and the skills to achieve the goal. Korcshnoy and Verner (2010) claimed that self-confidence is an important cause for successful learning in robotics projects. They believed students have mastery experiences when they achieve their goals through persistence, observe successful experiences of others, get appraisal from educators and feel the general positive spirit in the class. They added these experiences greatly affect the self-confidence of the learners.

Educators can obtain beneficial feedback from the learners' expectations and perceptions of their learning environment. Just as much as the willingness of educators to listen to the students' perceptions to modify their approaches will benefit the teaching-learning process, the reluctance to include them will tarnish it (Ahmed & Aziz 2009).

2.5 Pilot Study - Middle School Students' and Teachers' Perceptions of Learning to Program with Robots in a Private School in Abu Dhabi. (Full Study in Appendix H)

In the spring of 2012, a pilot study was conducted at a private school in Abu Dhabi. Participants included grade 8 girls from similar socio-economic status with fairly good GPAs. A qualitative study was conducted to explore the perceptions of middle school students and their teachers with respect to learning and teaching programming with robots. The study was conducted over a short period of two weeks. Data collection methods involved self-developed questionnaires, interviews and observations. Different data sources were used in order to triangulate, and thereby achieve more accuracy in the study (Creswell 2008). The teacher questionnaires contained questions regarding demographics and perceptions of robotic lessons. The interviews were used to collect information so as to validate questionnaire responses. Only one observation was conducted as a participant in the lab. The study involved observing the participants while they were engaged in an active robotics lesson in the lab. After the observed lesson, the students were administered with the questionnaires. As many students were ESL learners, some of the questions needed to be read out loud. Interviews were conducted the following week after another robotics lesson. The teachers involved in teaching these grades were also administered questionnaires and interviewed. Results were collated; categorized into codes and then analysed to form themes.

The results showed that only few students were motivated in the robotics lesson even though they all recognized its learning potential. Almost all found it boring or frustrating and all felt the need for clear guidance in tasks. Observation had revealed lack of structure in the lesson which was also perceived by most students. Contrary to Papert's (1980) statements, students didn't appear to be naturally technology-oriented. As claimed by Buckingham (2007), very limited transfer of skills was observed, again contradicting Papert (1980) who argued otherwise. Students and teachers equally agreed that there was no collaborative learning and students just waited for the teacher to tell them how to code, yet again refuting studies claiming that robotics promotes collaboration and teamwork (Barker and Ansorge 2007; Beer, Chiel & Drushel 1999). In addition, students generally agreed that they did not think about their activities once they left the lab. Teachers claimed they enjoyed teaching with robots and recognized their worth as powerful educational tools and acknowledged the variety of skills they can be developed using them. At the same time, they voiced concerns regarding structured lesson plans and the need of time to design them; in-class time to implement them and to connect to concepts in other disciplines. Both teachers and students identified lack of resources, lack of time and poor logistic set ups as barriers to an ideal robotics lesson. Teachers also expressed the need for assistance in the labs as well as pedagogical training in robotics. One interesting comment from the students was that they preferred the subject to be optional and ungraded. An interesting observation regarding the teachers was that they perceived that their students really enjoyed the lessons and were upset when lessons ended; which sadly was not the case. From this pilot study it was evident that the perceptions of middle school girl students are significant to improvise their learning environments and enhance their experiences to get maximum benefit from learning programming with robots.

This pilot study gave insights into designing the present study to explore perceptions of primary and secondary students. The questionnaires and interview questions are to be modified to suit the understanding of both. Primary students are said to be highly motivated due to their age, according to most research, so their perceptions will be reported from this viewpoint. In addition, the perceptions of secondary school students, who have taken the subject as an optional one in order to train for competitions after school, will be studied to assess their interest in STEM careers. Teachers seemed positive and enthusiastic in the pilot study but did not influence the middle school students. Their perceptions while teaching the primary and secondary students will also be explored.

Summary of the Literature Review

In summary, the review of literature revealed studies that promoted the inclusion of programming in schools. These studies described its benefits, in terms of motivation and development of other important life skills such as problem solving skills, collaborative skills and creativity. The studies also portrayed the connections between meta-cognition, learning and programming which emphasizes on the proper implementation of the subject into the curriculum to obtain the expected outcomes in the students. Some research however also revealed the failure of its implementation in schools given the attitudes of students and teachers; and other logistic problems in the schools. It deems significant to understand the perceptions of students and teachers to acknowledge their problems and thereby find solutions to them so that robotics can be appropriately included in the curriculum and successfully implemented in the schools; and therein lies the basis of this study.

CHAPTER THREE

METHODOLOGY

3.1 Research Method

This study was designed based on the middle school pilot study experience and conducted in the same school; however, with more participants and at primary and secondary levels. As before, in order to focus on themes and perceptions, a descriptive qualitative method was used. Creswell (2008) defined qualitative research as one that depends on participant views with large amounts of data that are described and analysed using themes; and the inquiry is subjective and biased. Qualitative research is process oriented, inductive in nature and is best to understand human behavior and experience (Bogdan & Biklen 2006). In the qualitative research method a case is studied systematically to give a rich description of the focus of inquiry (Boudah 2011), in this study, being students' and teachers' perceptions on the use of robots to learn programming in schools. Previous research studies (Petre & Price 2004; Robinson 2005) that looked into perceptions have used this method successfully to describe the feelings and experiences of the participants. This method is the best to know the process of change in a school and how change is experienced by the various school members (Bogdan & Biklen 2006).

3.2 Ethical Issues

Ethics should always be considered throughout the research process, be it in respecting participants, honouring research sites or in the reporting of results (Creswell 2008). The researcher sought permission to conduct the study from the school authorities. In qualitative study, participation is voluntary with informants understanding the nature of the study, its dangers and obligations (Bogdan & Biklen 2006). Before the interviews and the questionnaires, the researcher explained the purpose and consequences of the study to the students and teachers, emphasizing that it was voluntary for them to participate. The interviews and questionnaires were done during the last quarter of the lessons with no loss of instructional time. Students and teachers were promised complete confidentiality and anonymity.

3.3 Gaining Access

Permission to conduct the study was sought at the beginning of the academic year from the school authorities and the IT department. Detailed descriptions of the procedures were reported to the administration, informing the benefits and potential risks of the study to the site and people. Promise of anonymity and confidentiality of the participants as well as the school, was also discussed. Letters were sent to parents stating the purpose and benefits of the study; including that participation was voluntary. The IT coordinator was identified as the gatekeeper and was informed about the length of the study, the number of visits and the time per visit. Teachers were communicated with the purpose of the study and consulted to decide the appropriate sections of students to be studied which would provide a good blend of Emiratis, Asians and other Arabs with fair GPAs. They were also referred to discuss convenient timings and locations for the study.

3.4 Participants

The participants included 53 female students from Grade 5; and 12 female students from Grade 11. The students had no prior experiences in robotics and were only introduced to construction and programming in these sessions. The primary students have been introduced to basic computer skills since grade 2. The secondary school students have been taught information technology as a core curriculum subject in years 7, 8, 9 and 10. All students were generally found to be very comfortable with technology in the classroom.

Six teachers, who were instructors in the Robotics labs were also included in this study. All teachers were used to technology in classrooms in the form of smart boards and laptops. None of them had any previous experience of teaching with robots.

3.5 The Present Study

The study was conducted at the Primary and Secondary IT labs in a private school in Abu Dhabi comprising of a good blend of Emirati, Arab and Asian students. The primary school students were taking Robotics classes as part of their ICT curriculum only during the second term. During the other two terms they were learning basic computing skills and Microsoft Office packages. The secondary school students had Robotics classes as an optional subject during the same term, in order to prepare them for an upcoming robotic competition.

They had their classes after school in the IT labs. The students were divided into groups randomly by their teacher and each group was provided with a robotic kit. Questionnaires were used to explore students' and teachers' perceptions and attitudes using robots in the labs to learn programming. The purpose of the study was explained to the students. Interviews were also conducted with the students and the teachers in order to validate the questionnaire responses. Furthermore, observations were conducted of the Robotics classes.

This study involved three observations of each class during the term with interviews conducted at the end of lessons. Contexts are very significant in this kind of study as human behavior is significantly influenced by the environment in which it occurs (Bogdan & Biklen 2006). Interviews were focused on their feelings immediately after the lessons to identify their experiences and reflections. Data collection further comprised of questionnaires undertaken by the students at the end of the term regarding their perceptions of the robotics classes. The questions in the questionnaires were read out and explained with examples as many students were English as Second Language (ESL) learners. The data collection methods are explained in detail in the following section.

Most of the students in the study had no idea of robotics and what they would be doing in these classes. Students were introduced to basics in robot-building and programming concepts. They had hands-on experience in the designing, building and testing procedures with oppurtunities to develop programming skills to control the robots' movements using different motors and sensors. In the primary school, robotics classes were conducted for a period of eight weeks during school hours, with two weeks for building concepts, four weeks for programming concepts and the last two weeks for reinforcement of topics covered and assessment. Their lessons included two parallel components of lecture and practical, each 40 minutes in duration. On the other hand, the secondary school students had 2 hour robotics lessons for eight weeks, after school, right up to the competition. These students had specific guidelines to follow, provided by the competition conductors. Since the focus of this study was on the experiences of students with using the robots as educational tools, the researcher remained as one of the teachers (as a participant researcher) in both the levels, behaving as a facilitator, providing guidance, administering practical work and also answering when questioned. General observations regarding the dynamics of the class during the lessons were made and recorded. In the primary school, the lecture lessons included topics like basic robotic concepts, programming concepts, robot accessories and connectivity. The practical lessons followed allowing students to explore and apply the concepts presented in the lectures. Students built the basic robots in the first two weeks referring to the building guides available in the kits. They were explained the workings of the motors, sensors, gears, ports and cables. They were also told that when they become competent in the subject they can change the mechanical design of the robots depending upon the program they were planning to write. In the secondary school, the lessons were conducted in a similar fashion but they had only two weeks to be familiar with the building and programming concepts and the following weeks they had to concentrate on the specific activities required for the competition. In this way students were studied while they worked in groups of three and four, performing roles of programmers and engineers. At the end of the term, students were asked to reflect on their experiences in focus group interviews and also to fill in questionnaires to record their opinions and suggestions. The teachers involved were also administered questionnaires and individually interviewed to identify attitudes and issues concerning their experiences.

3.6 Data Collection Techniques

The data collection methods that were used in this research included questionnaires, interviews and observations. By using these three methods, triangulation was expected to be achieved. Triangulation across data sources, help in increasing the truth value or confirm the findings of any study, thereby enhancing its accuracy (Boudah 2011; Creswell 2008).

Questionnaires **(APPENDICES A, B, C)**

This study drew on data from researcher developed questionnaires which were tested for reliability and validity in the pilot study. Few changes were made with respect to primary and secondary school student differences. Open-ended as well as close-ended questions were included. The former allow for participants to respond in detail based on individual experiences without restricting their views (Creswell 2008). The questionnaires have questions based on Student Perceptions of Classroom Quality (SPOCQ), which according to Gentry and Owen (2004) assess the perceptions of students based on meaningfulness, challenges, preferences, self-efficacy and attraction value. These constructs are vital for outcomes in education in relation to student achievement. They have recommended its use in schools to assess perceptions, evaluate classroom quality and conduct educational research.

The student questionnaires were designed to collect information such as students' understanding of the meta-cognitive skills involved and problems associated with robotics;

and on attitudes when working with robots to learn programming. The former information was collected with the students checking one or more items listed and then elaborating on them. The latter was collected using a 3 point Likert scale for Primary and a 5 point Likert scale for Secondary students. Each item was a short statement about using robots to learn programming and students were asked to choose one of the three or five choices in order to evaluate the students' level of agreement or disagreement to that statement. Few questions were open-ended which allowed the students to respond based on their own experiences and beliefs. The questions were designed simple and clear to make the task of filling out the questionnaire easy and less complicated. The questionnaires were filled in immediately after the robotics lessons where the items were read out and explained whenever necessary to the students. All the questionnaires were completed and returned back immediately.

The questionnaires for the teachers had two parts, one which included items regarding demographic information including years of experience, educational background, their highest qualification and ICT knowledge and training; and the other part had questions about the advantages and disadvantages of using robots, teachers' perceptions of their use in classrooms with students; and their challenges compared to traditional methods of teaching. Some questions were open ended or questions that involved the teachers checking one or more items and elaborating on those; and other questions were 5 point Likert scales to identify their agreement or disagreement to mentioned statements.

Interviews **(APPENDICES D, E & F)**

Interviews are a fitting way to get information about beliefs, views and perspectives (Boudah 2011), therefore well warranted in this research. Open-ended yet structured interviews will be conducted to allow students as well as teachers to express themselves freely to researcher's specific questions. Also, with these kind of interviews participants may lead researchers into areas not considered earlier (Boudah 2011). Creswell (2008) claimed that with open ended questions, participants express their experiences uninhibited by the researcher's perspectives or previous research findings. Focus group interviews were conducted in this study to collect shared understanding from groups of three or four students lasting approximately 15 minutes each. All students were given turns to talk and encouraged to participate. The main topics touched upon during these interviews were

a. General attitudes towards robotics,
b. Problems faced during lessons
c. Advantages and disadvantages of using robots in classrooms

d. Effectiveness of robotics to learn programming
e. Suggestions for better use.
f. Identification of any connections with other subjects
g. Career options and relation of their decision to robotics lessons (Only secondary students)

Teacher interviews were one-to-one, where the topics included their general attitudes towards teaching programming with robots. In addition they were asked about the advantages and disadvantages of using robots in classrooms and also the skills they believed robotics can enhance. They were asked to enumerate the problems they faced and put forth suggestions for better use. Lastly they were asked about students' perceptions of the robotics classes.

Observations **(APPENDIX G)**

Observations are supreme in qualitative inquiry (Boudah 2011). Observation is a means to gather open-ended, direct information by just observing the participants and the site. It is a frequently used method of data collection allowing the researcher to assume many roles (Creswell 2008). While this method provides first hand information, it has its disadvantages in that the researcher is limited to sites where access is gained. Also observations require good listening skills and attention to details, in addition to the ability to manage issues such as potential deception by participants in the site. In this study the researcher assumed the role of participant observer, assisting the teacher so as not to distract the students. Teacher-student interaction, peer interaction as well as class dynamics were observed. It was noted that, to make the most of the observation the researcher needed to shift roles from participatory to non participatory and vice versa, in order to focus on key issues at intervals and move around to observe student interactions and address their questions. The researcher recorded observations occasionally during the lesson.

Three observations each were made randomly in two classes in the primary school conducting robotics lessons on different occasions during the second term. Three observations were made in the robotics lessons of the secondary school. Each observation lasted for 80 minutes. The observation tool was researcher developed and consisted of four parts:

1. Time interval
2. Teacher role
3. Student organization and level of engagement

4. Researcher’s reflective notes

3.7 Data Analysis

Theories of Constructionism, Zone of Proximal Development and peer learning formed the theoretical background of this study. Qualitative research is inductive (specific to general), iterative (moving back and forth between data and analysis) and interpretive (depending on researchers interpretation) in nature (Creswell 2008). All data were first organised, then coded with labels describing the general sense of the data. Similar labels were categorized together to get themes. These themes were examined and finally the relevant experiences of the students and teachers when they use robots as educational tools to learn programming in schools were reported.

Students’ Questionnaires

All data from the students’ questionnaires were summarised into codes. The summarised results are presented in the Results chapter that follows. These results were combined with the focus group interview excerpts and observations to form themes.

Teachers’ Questionnaires

All data from the teachers’ questionnaires were summarised into codes. The summarised results are presented in the Results chapter that follows. These results were combined with teacher interview excerpts and observations to form themes.

Focus groups

The focus group transcripts were put into meaningful segments identifiable with words or phrases. These segments were coded according to themes identified before the study. New codes that were generated during the focus groups were added. The following categories were identified:

a. Attitudes towards robotics and programming
b. Technical problems during lessons

c. Teacher strategies
d. Meta-cognitive skills development
e. Team work and Collaborative skills
f. Suggestions for better use

This coding scheme was applied in all the transcripts of the focus groups.

Teacher Interviews

Selected segments of teacher interview transcripts were identified as attitudes towards robots and programming; and classroom processes. Excerpts from attitudes included advantages and disadvantages of use of robots; benefits of teaching programming and perceived interests of students. Excerpts from processes include lesson structure, problems in classrooms and skills developed during lessons. The analysed data of every teacher interview transcript were combined with that from teacher questionnaires to form themes again.

Observations

The robotics lessons' observations were analysed for each class and then combined to obtain final results that is presented in the next chapter. The timed interval observations were analysed for categories and results represented as percentages. The summarised percentages are presented as tables. Other data was presented in chart forms for the sake of clarity and easy retrieval. Data collected from the observation notes were used to elaborate the results.

Chapter FOUR

RESULTS

4.1 Students' Perceptions on Using Robots to Learn Programming

Students' attitudes and beliefs towards use of robots to learn programming were one of the objects of focus in this study. With this purpose in mind, data from the student questionnaires, classrooms observations, and the focus groups interviews were reviewed together and triangulated for valid results.

Primary Students

Fifty-three (N=53) of the 55 students responded to the questionnaires. Two were absent. Two classes were observed to get a good blend of students from Asia (India, Pakistan and Sri Lanka), Emirates and Arabs (Lebanon, Syria, Egypt and Jordan).

Feelings towards Science and Maths subjects

In response to the question that asked if the students liked the subjects Maths and Science, 60% answered positively. 35% students liked either Maths or Science. Only 2 students said 'neither'. The same percentages were found in the interview responses as well. When asked if they connected robotics lessons to Maths and Science concepts, 50% said 'yes'.

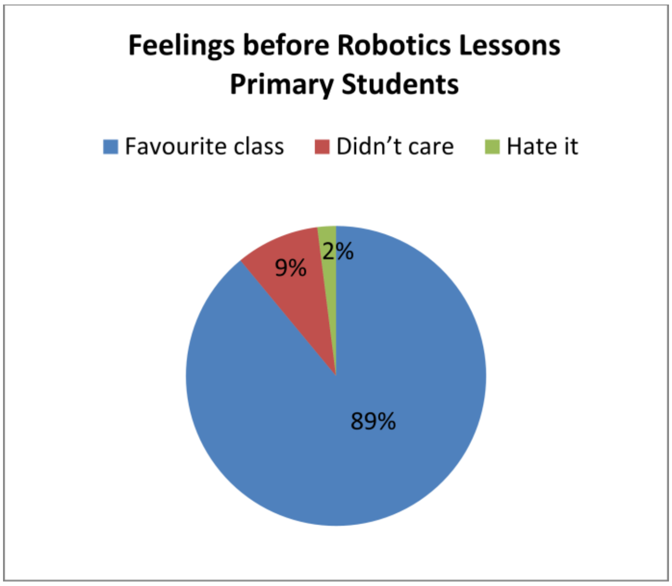
Interest, motivation and engagement

In response to the question that asked if students looked forward to Robotics classes, 89% responded 'It's my favourite class'; 5 students out of 53 didn't care and only one claimed she hated it (Chart 1a). The interview responses showed that 86% were more interested in Robotics than in ICT classes and 12% preferred ICT over programming and the remaining didn't mind either.

The observation notes showed that all the students were very keen to come to the robotics lessons. However the Asian students settled down quickly to begin the lesson but the Emiratis and Arabs needed coercing to settle in.

Chart 1a-

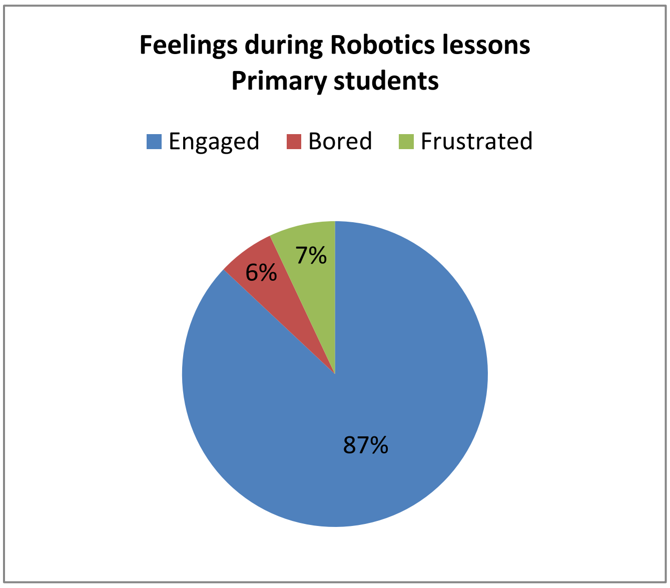
Feelings before Robotics Lessons Primary



In response to the questions that asked about their feelings when working with the robots, 87% responded that they were interested and 13 % claimed they were either 'bored or frustrated' (Chart 1b).

Chart 1b -

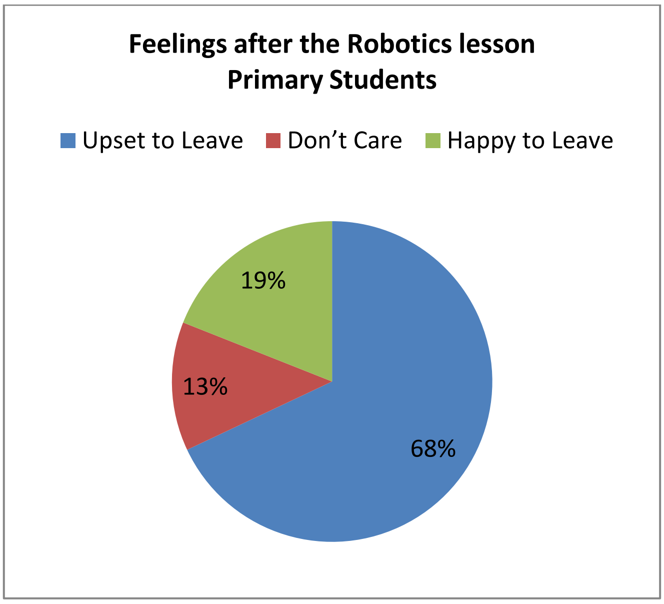
Feelings during Robotics lessons Primary



During the lessons, it was observed that the Asian students could recollect well, the information learnt in the previous lessons and all the groups achieved their tasks in time. However, the class with the Arab and Emirati students needed more prompts and explanations. The students did achieve the tasks but only 20% did so without any help. The others went off task 85% of task time and eventually got the teacher to help them code. However, the groups that did achieve their tasks were able to move on to extended activities and achieve higher goals, not intended or even expected by the teacher.

When questioned about their feelings when leaving a robotics lesson, 68% claimed they were 'upset', and the remaining were 'happy to leave' or said 'don't care' (Chart 1c).

Chart 1c -
Feelings after the Robotics lesson
Primary



The observation notes did not reveal any students as unhappy to leave the robotics lessons.

Metacognition

In response to the question if they understood why they were learning to program with robots, some of the responses were as follows:

- *'to learn about robots'*
- *'it is important for future'*
- *'to understand working of other devices'*
- *'to think'*
- *'to learn to solve problems'*
- *'to participate in competitions'*
- *'did not know'*
- *'to be promoted to the next grade'.*

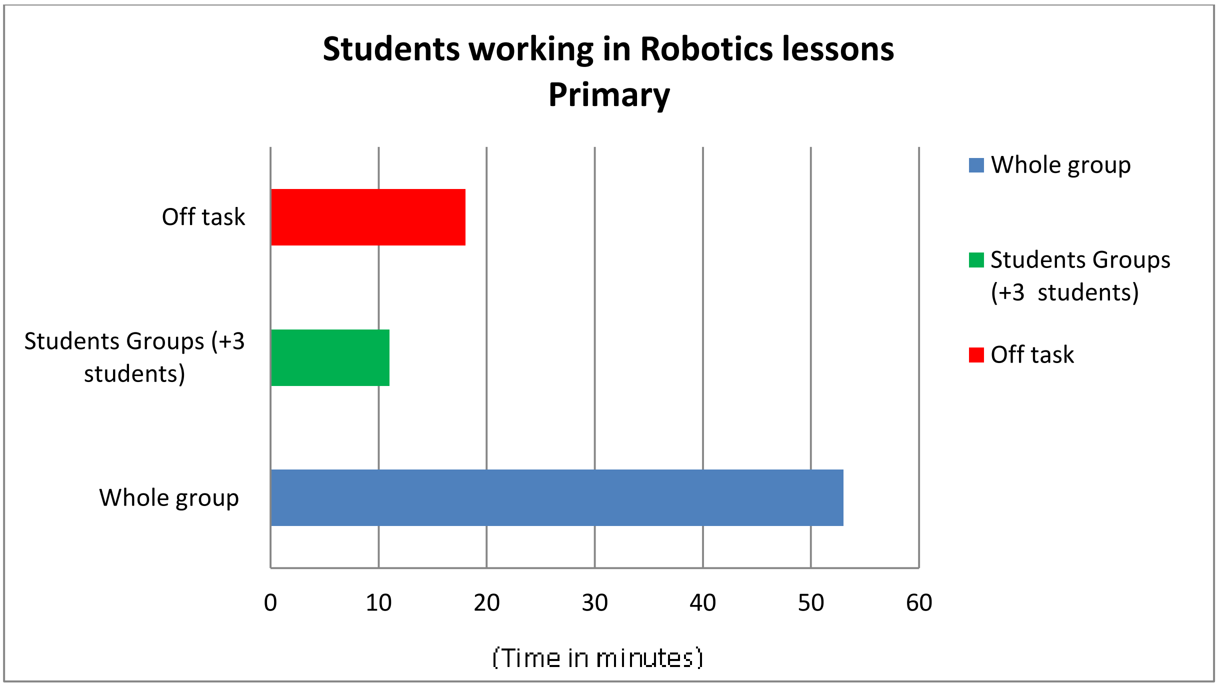
When questioned regarding the skills learnt in robotics lessons given the choices of creative, critical thinking, problem solving, building and general computing skills,

- 60% chose creative skills stating different kinds of robots can be created doing different actions based on one's imagination and creativity.
- 66% chose critical thinking skills stating that one needs to think in many ways to create different robots to do different actions.
- 70% chose building skills stating that one must know how to build and connect.
- 36% chose problem solving reasoning that one solves the problem when robots don't do what they are programmed to do.
- 37% chose general computing skills.
- Only ***two*** students identified team work and collaboration stating '*we discuss and decide what to try'*
- One student said *'to learn how things work'*

When questioned if they reflect or think about the class later, only 34% said 'always', 51% responded 'never', the remaining saying 'sometimes'. The interview responses however showed 77% students saying 'yes' and remaining 23% 'no'.

83% of the students recognised that the robots had both learning and playing aspects to them and 17% identified only the learning associated with it.

Chart 2a – Primary Students organisation w.r.t time in Robotics lesson



Teacher issues

In response to the question whether the tasks are clear, 64% students responded ‘very clear’, 32% said ’just ok’ and only 2 students (3%) said they did ‘not have a clue’. The interview responses:

- 74% claimed ‘very clear’ and
- 26% said ‘not clear’.

The observation notes suggest that 6 - 7 students in each class observed, seemed frustrated or bored. The students stopped working and moved around talking to each other or started working on other programs.

In response to the question if the teacher encourages critical thinking, only 32% affirmed ‘always’ while 62% were ‘not sure’ and again 3 students (6%) claimed ‘never’.
In interviews:

- 53% students said ‘Always’
- 23% said ‘Sometimes’
- 24% said ‘Never’.

Observation notes revealed that the teacher spent less than 15% of class time in encouraging critical thinking skills.

Problems with the lessons

In response to the question if there were any problems in the Robotics classes, the following were mentioned:

- poor classroom management
- low battery life
- no software in some laptops
- low memory on the robot
- too noisy to use sound sensor
- teacher unavailability

Interviews yielded:

- *‘some robots are wobbly and break when we do trials with them’*
- *‘sometimes the programs just don’t work’*
- *‘we need more time’*
- *‘it’s so noisy that the sound sensors don’t work’*

The observation notes revealed similar data with the classroom noise disrupting the working of the sound sensors; the robots not working due to low battery; technical issues such as low memory in the NXT brick; unstable robots; students calling out for assistance together but teacher can only guide one after the other etc.

Teamwork and collaboration

In response to the questions if they discuss the programming with friends within the group, 91% said 'always' or 'sometimes' and only 5 students claimed 'never' and if they discuss with other groups when they have problems 53% claimed 'always with the rest saying 'never'. However, interview responses state that all students (N=53) answered positively with respect to discussing within group. Observation notes confirmed that most groups were discussing with each other when planning and programming.

Secondary Students

All (N=12) of the **Secondary students** responded to the questionnaires. All of them were Arabs from Lebanon, Palestine and Egypt. All the students claimed that both their parents were employed.

Student subjects and Career interests

All students (N=12) who had opted to take robotics to prepare for the competition have also chosen Maths, Science and ICT as their O levels subjects.

In response to their career choice, 8 out of 12 students are considering Engineering or Medical studies as their options. Four remain undecided.
Interviews added that six of them decided to follow these careers after participating in the robotics lessons.

Interest, motivation and engagement

All Students (N=12) either liked robotics lessons a lot or said it is their 'favourite class'.
Regarding their feelings while working with robots, 10 (83%) confirmed they were engaged and involved in the lesson; only 2 felt 'slightly frustrated'; none were bored.

When questioned regarding their feelings when leaving the robotic lessons, 6 (50%) students responded that they were 'slightly upset', 4 (33%) had 'no feelings' at all and 2 (17%) were 'slightly relieved'.

The interviews confirmed their interest in doing robotics with comments like

- *'it's optional; so it's our choice to do it'*
- *'we feel that we are achieving something always'*
- *'it's amazing'*

Two girls in the interview said that they did not like it so much in the beginning

- *'we found it hard but later when we began to do more, we really enjoyed it'*

In the interviews all (N=12) confirmed that they enjoyed Robotics and added that they preferred the programming aspect to the construction.

The observation notes revealed that all the students were engaged during the lessons and the students were never satisfied to leave. They seemed unhappy to leave the program incomplete and always asked *'Is it time to leave already?'*

Metacognition

When questioned why they are taught programming in schools, students' responses were

- *'for participating in the competitions'*
- *'to help in the future careers'*
- *'to understand the working of other devices'*
- *'to solve problems in real life'*
- *'to think critically'*

Responses to the question 'why they think they are taught programming using robots' were

- *'To participate in the robotics competitions'*
- *'To be able to relate robots to real life to solve problems'*
- *'Robots are fun'*
- *'Robots represent the future'*
- *'Robots enable teaching programming easy'*

In response to what skills are taught implicitly while learning to program with robots with examples, detailed responses came to the fore such as the following:

- 83% of the students chose creative skills as
  - *'there are different ways to attach parts'*
  - *'we can make self designed original robots'*
  - *'we can make beautiful and useful designs'*

- All (N=12) chose critical thinking skills as
  - *'in robotics there no set limits; we can make anything!'*
  - *'we had to think a lot to create a robot with minimum steps to do a job'*
  - *'during competitions we are pressured to come up with solutions on the spot'*
  - *'the working of sensors needed to be well thought of'*

- All (N=12) chose problem solving skills as
  - *'we had to fix programming problems'*
  - *'we face and solve many problems in the programs as well as the building of robots'*
  - *'mostly in competitions we have to design robots to solve problems'*
  - *'programming means to solve a problem logically'*

- 83% chose designing skills as
  - *'we had to plan before we build or program the robots'*
  - *'we had competition rules to follow in the robot design'*
  - *'the structure of the robot had to be planned practically'*

- All (N=12) chose constructing or building skills as
  - *'we had put parts together to build'*
  - *'stable robots had to be built'*
  - *'we had to learn to construct our own unique robots at the competition'*

- 50% chose ICT skills as
  - *'we used the laptops and software to program'*
  - *'we used USB, laptops and programming software to program and download onto the robot'*

- Only two girls mentioned team work and collaboration as other skills

Interviews revealed that all the girls recognized the team work and collaborative skills required to participate and win in the competitions. Some girls mentioned that it was a skill encouraged by the teacher. Others said they discussed with their older siblings to get ideas.

All (N=12) students recognized the playing and learning potential in programming with robots, 8 (67%) agreed that both were equally present; 2 (17%) identified more playing potential than learning and an equal (17%) thought vice versa.

When questioned if the students planned or designed before the building and programming the robots;

- 67% answered *'most of the time'*
- 17% responded *'sometimes'* and
- 17% responded *'always'*.

Interviews confirm the above statements with one student saying that

- *' we have to design first or else we will not be able to figure out what the problem is if something goes wrong'*
- *'Programming is done step by step so we must design these steps first'*

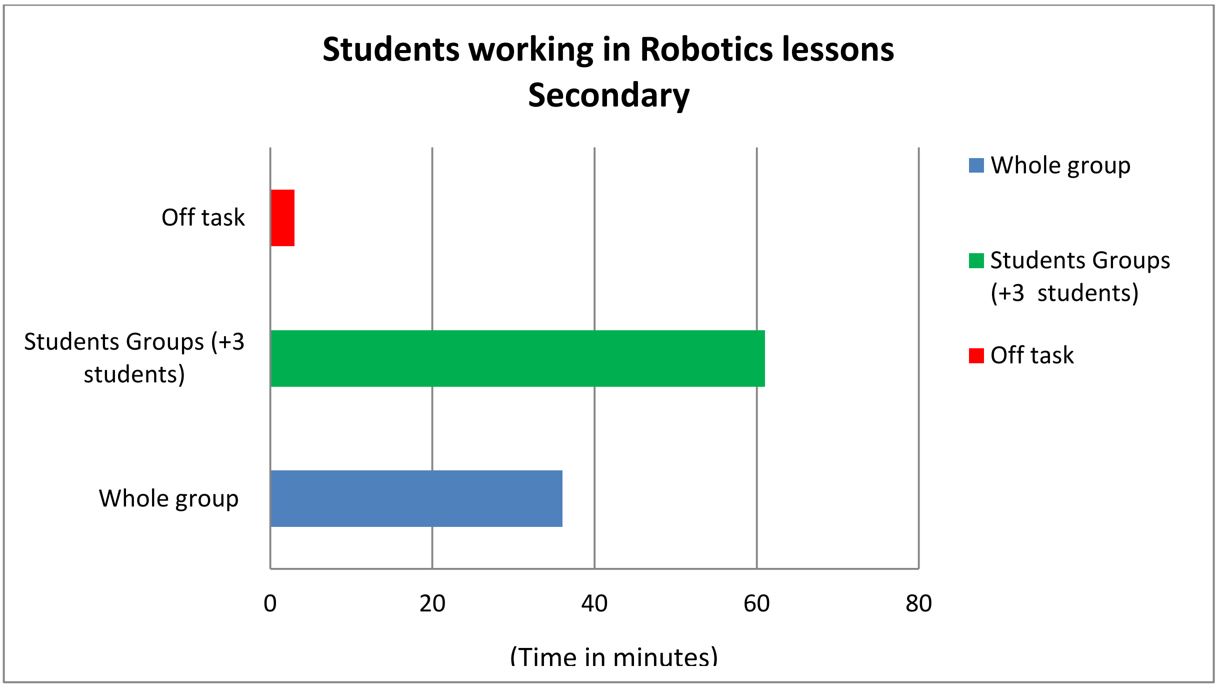
Observation notes also show that the students used to design the structure of the robot as well as the programming logic.

When asked if the students reflect on their lessons after the classes, 33% claimed *'always'*, 50% responded *'most of the time'* and17% said *'sometimes'*.

Interviews confirmed the same as the students said they

- *'discussed with friends in the cafeteria'*
- *'asked siblings for help in logic'*

Chart 2b- Secondary students organization w.r.t. time in Robotics lesson



Teacher issues

In response to the question if the classes were well structured, 6 (50%) students believed they were *'very well structured'* and the remaining thought they were *'fairly structured'.*

When questioned if the robotics teacher encourages critical thinking, 8 (67%) of the students believed the teacher did *'most of the time'*; 2 (17%) believed they *'sometimes'* did and an equal percentage confirmed they *'always'* did.

Interviews revealed that students believed that

- *' teachers asked us to think in many ways how the program could be wrong'*
- *' the teachers had to, as we were on our own during competitions'*

Observations noted that the teacher did encourage students to think critically while designing as well as when the robots did not work according to the programs.

Problems in using robots to learn programming

Regarding any problems in the Robotics lessons, the students responded with

- *'the need for laptops exclusively for these robotics lessons'*
- *'continuous time to work with robots as they were coming in during breaks and free lessons in addition to the after school sessions to complete programs'.*

In the interviews the students said they

- *'needed continuous time to work'*
- *'needed robotics labs as now we are working after school in the normal IT labs and sometimes we lose our programs'*

Observation notes revealed that these students needed continuous blocks of time as well as more resources in terms of software and space. The software was stored in PCs in the IT labs and the students sometimes found the software or even their programs missing.

Teamwork and Collaboration

In response to the question if the students discussed with their group members when encountered with problems, 2 (17%) confirmed they did *'always';* 8 (67%) responded they did *'most of the time'* and the remaining students claimed *'sometimes'*.
In response to the question if the students discussed with members of other groups when encountered with problems, all (N=12) responded *'always'*.

In the interviews students said

- *' the teachers always asked us to discuss and work, so we are used to it now'*
- *' two of us are sisters so we continue our discussions at home'*
- *'we need to discuss to come up with solutions quickly during the competitions'*

Observation notes reveal that students discussed with each other. They assumed roles as programmers, builders and robot testers and discussed from these perspectives. When programs did not work they always went to the other group and ask questions.

4.2 Teachers' Perceptions on Using Robots to Teach Programming

Primary School Teachers

Demographics

All teachers (N=3) responded to the questionnaires.

Two the teachers (66%) have more than 11 years of experience in teaching. All have international qualifications in teaching and all are ICDL qualified. All of the teachers hold Masters Degree in their respective subjects.

All the teachers claimed they take between 2- 5 hours to prepare for the Robotics lessons.

Skills enhancement in students

Two teachers (66% of the teachers) believed that creative and ICT skills were enhanced while students work with robots while all (N=3) believed that critical thinking, problem solving and designing skills were enhanced. The other skills that they believed were also enhanced include

- *‘team work and collaboration’*
- *‘taking of ownership of results’*

All teachers (N=3) perceived that students were motivated, engaged and interacted well in groups. One teacher commented:

- *‘it was nice to see students explaining to one another with their group’.*

None of the teachers believed that the students connected Robotics concepts to Maths and Science as:

- *‘they are too young to make such connections’*
- *‘the interface is too ICT oriented’*
- *‘we do not make any connections as we are concentrating only on teaching them programming’*

All teachers believed that students were ‘learning to learn’ while in a Robotics lessons with comments such as:

- *‘without being aware that they are learning’*
- *‘it’s possible but only with well structured lessons’*

In the interviews teachers also added:

- Motor skills
- Time management skills
- Social skills
- Logical thinking skills

Observation notes yielded that when the task was to just move forward and turn, some students achieved this and went ahead to make the robot move in a square using the loop function.

Problems in the Robotics lessons

All teachers (N=3) perceived there were classroom management issues with a few students uninterested in the subject and thereby causing disturbances. All teachers also noted lack of time, open space and any assistance in the labs to solve technical problems or to attend to minor issues, as some of the problems encountered in the lessons.

All teachers answered they had sufficient resources in terms of robots, software and laptops.

In the interviews teachers mentioned:

- *'Uninterested students causing chaos in the class'*
- *'Wastage of time in class to repair robots dismantled or broken by other class students'*
- *'no adult support to help with technical or software issues during the class'*
- *'no time or resources to use with special needs children'*
- *'no time to attend to many groups'*

Teacher feelings regarding robotics

All the teachers believe that Robots are powerful teaching tools. They reasoned as follows:

- *'because children are working with real machines, they are involved and therefore they are learning unlike when they have to learn concepts by rote'.*
- *'students are motivated as they are working with stuff they can touch and also they are working together so they are building knowledge together'.*
- *'robots push children to planning, critical thinking and decision making unknowingly'.*

One teacher (33% of teachers) answered 'slightly confident' while 66% answered 'confident' or 'very confident' when asked about their feelings before the Robotics lessons in comparison to ICT lessons.

All teachers (N=3) answered 'very confident' when asked about their feelings before the ICT lessons.

One teacher (33% of teachers) answered 'slightly confident' while 66% answered 'confident' or 'very confident' when asked about their feelings during the Robotics lessons.

One teacher (33% of teachers) answered 'satisfied' while 66% answered 'quite satisfied' or 'very satisfied' when asked about their feelings after the Robotics lessons is over.

Interviews and observations revealed that all teachers enjoyed teaching with robots much better than teaching ICT skills. Regarding the changes made in the GCSE ICT curriculum, all the teachers had mixed feelings with comments:

- *'that programming must be the main focus with ICT literacy and skills also included'*
- *'all students do not have the skills to program and excel in the same.'*
- *'we need ICT literacy and skills for daily use'*

Teachers' perceptions of Students' perceptions

All teachers answered 'interested', 'very interested' and extremely interested' when questioned how they perceive their students' attitudes before they come to the Robotics lessons.

Each teacher perceived the students differently when questioned how they felt when the Robotics lessons were over; one said 'relieved' and the other two said 'no feelings' and 'slightly upset to leave'.

All teachers believed that the students were engaged only when they were actually working hands on in the Robotics lessons.

From the interviews teachers believed that students had high levels of interest because of robotics was a new concept. Some of the comments include:

- *'robotics enhance the competitive spirit for average learners and the satisfaction of achievement for the advanced learners'*
- *'students are interested because its challenging and they are participating actively. Even the parents are keen about their children learning to program with robots'*

However, teachers also believed that programming was not for everyone with comments such as:

- *'by forcing all students to learn programming, they might not learn anything. They will get frustrated.'*
- *'some students just take robots as toys with no learning involved'*
- *'no scope with special needs children'*

In the interviews teachers mentioned:

- *'most of the students are interested and engaged'*
- *'when I put the uninterested or lazy students together in a group, they achieved atleast the basic tasks which was commendable'*

Teachers' roles

All teachers perceived their roles in the Robotics lessons as lecturers, facilitators and lab technicians. In interviews they perceived themselves as more of facilitators than anything else. Observations showed they facilitated for very little time compared to other roles (Chart 3a).

Two of the teachers (66% of the teachers) claimed they asked the students to solve the problems themselves while one teacher claimed that she went to them immediately.

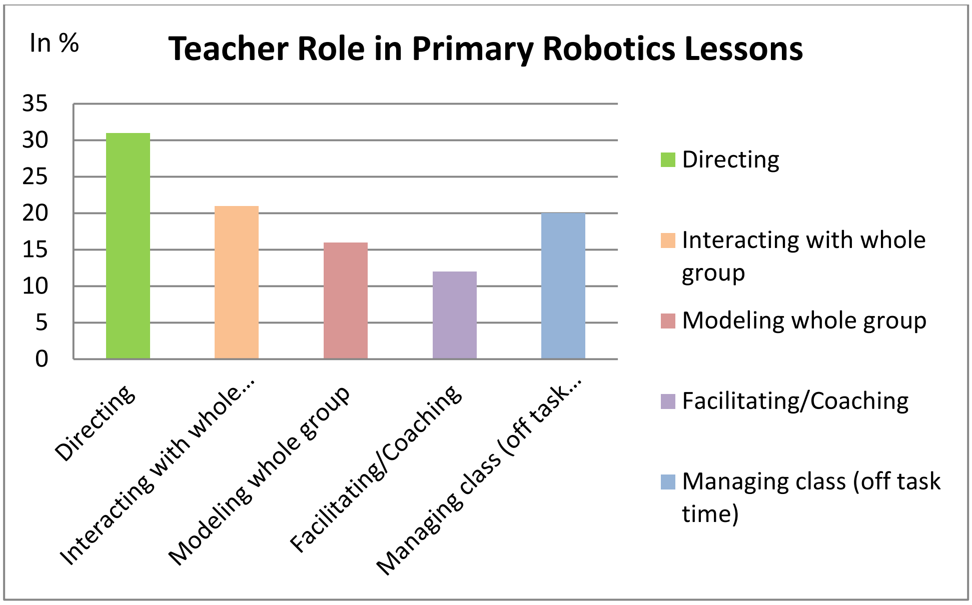


Chart 3a – Teachers roles in a Robotics lesson - Primary

Lesson structure

Interviews and observations revealed that the teachers started every lesson with a recapture or reinforcement session, then an introduction to the present day's topic moving on to an in-depth discussion and modeling of the task. This was followed by student's task and testing phase and finally a conclusion with a discussion of problems encountered and solutions

None of the teachers prepared for variability in the class as they claimed they did not have the time. Also they stated that these were introductory classes so they were just analyzing the variations in the class. However, as a general rule the high achievers were asked to mentor other groups and the low achievers were reinforced with worksheets.

Teacher training

- None of the teachers received training on how to teach programming with robots and all of them believe they needed training in the same.

Suggestions by the teachers

- Lab assistants or lesser class sizes
- Robotics lessons for more than a term

- Open space and dedicated labs with large tables and shelves to store machines and accessories
- Block hours of time to enable students to think and teachers to encourage thinking skills

Secondary School Teachers

Demographics

All teachers (N=3) responded to the questionnaires.

Only one teacher has more than 11 years of teaching experience. The other two have less than 5 years teaching experience. Only two have international qualifications in teaching and are ICDL qualified. Only two of the teachers hold Masters Degree in their subject.

All the teachers claimed they take between 1-3 hours to prepare for the Robotics lessons.

All the teachers believe that Robots are powerful teaching tools. They reasoned as follows:

- *'it develops thinking and problem solving skills'*
- *'some students are really interested'*
- *'students are learning without realising'*

Skills enhancement in students

Two teachers (66% of the teachers) believed that creative and critical thinking skills were enhanced when students work with robots while all (N=3) believed that problem solving and designing skills were enhanced. The other skills that they believed were also enhanced include

- *'cooperation'*
- *'logical thinking'*

All teachers (N=3) perceived that students were motivated and engaged.

All teachers (N=3) believed that students were *'learning to learn'* while in a Robotics lessons.

Problems in the Robotics lessons

All teachers (N=3) perceived there were few resources in terms of software and laptops; lack of time, and open space as some of the problems encountered in the lessons.

In the interviews teachers added:

- *‘as students used IT labs, their programs were lost and sometimes even software is missing’*
- *‘students work in short blocks of time which is not good for developing ideas and programs ’*
- *‘technical issues with robots wastes a lot of time’*

Teacher feelings

All teachers (N=3) answered ‘confident’ when asked about their feelings before the Robotics lessons in comparison to ICT lessons.

All teachers (N=3) answered ‘confident’ when asked about their feelings before the ICT lessons.

All teachers (N=3) answered ‘confident’ when asked about their feelings during the Robotics lessons.

All teachers (N=3) answered ‘satisfied’ when asked about their feelings after the Robotics lessons is over.

Interviews and observations revealed that all teachers enjoyed teaching with robots much better than teaching ICT skills.

Regarding the changes made in the GCSE ICT curriculum, all the teachers believed that it was good with comments:

- *‘that programming is good as the students are bored with ICT especially the ESL students’*
- *‘programming entails many skills compared to ICT literacy and skills’*
- *‘programming with robots is a better idea in schools’*

Teachers’ perceptions of students’ perceptions

All teachers answered ‘very interested’ when questioned how they perceive their students’ attitudes before they come to the robotics lessons.

Two teachers (66% of the teachers) perceived the students were ’relieved’ and the other said they were ‘slightly upset to leave’ when questioned how they felt when the robotics lessons were over;

All teachers (N=3) believed that the students were engaged throughout the robotics lessons.

From the Interviews teachers believed that students thought robots were fun and were motivated to work with them. Some of the comments include:

- *'robotics is very motivating for middle and high achievers'*
- *'since the students are here by their choice and not force, they are very interested'*
- *'creativity is only there if students are interested which is possible if subject is optional'*

Teachers' roles

Two teachers (66%) perceived their roles in the robotics lessons as lecturers, facilitators and lab technicians and one teacher saw herself as only a 'facilitator'. In interviews they perceived themselves as facilitators and guides. Observations confirmed their roles as facilitators during most of the lesson (Chart 3b).

Two of the teachers (66% of the teachers) claimed they asked the students to solve the problems themselves while one teacher claimed that she asked them to discuss with peers.

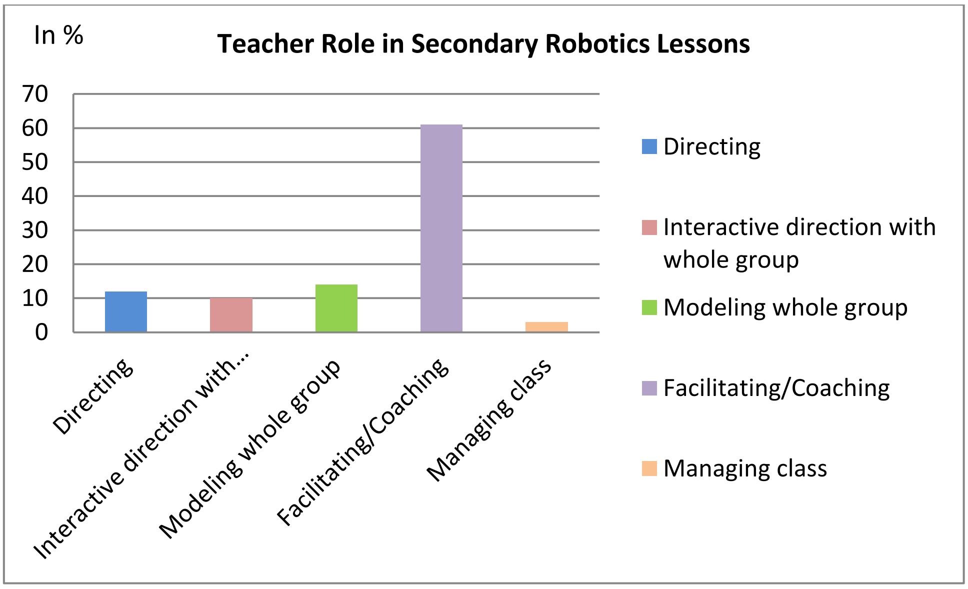


Chart 3 b – Teachers roles in a Robotics lesson – Secondary

None of the teachers were prepared for variability as the students were all high achievers who chose to be in the competitions and there did not seem to be any need.

Lesson structure

Interviews and observations revealed that the teachers started every lesson with an introduction to the present day's topic with task-sheets, then a quick questioning session of predictions and assumptions; and then modeling of the task. This was followed by student's programming and testing phase and finally a conclusion with solutions on the smart board including reinforcement of concepts.

Teacher training

- None of the teachers received training on how to teach programming with robots and all of them believe they need training in the same.

Suggestions by the teachers

- Robotics lessons to be introduced as an optional subject in the curriculum
- More resources, testing space and dedicated labs
- Time for teachers to prepare lessons
- Block hours of time for students to work continuously

In the interviews teachers mentioned:

- *'low achievers will find it difficult and teaching them frustrating, so it must be offered as an optional subject only.'*
- *'to get full advantage, more time and less students is important'*
- *'time and support, as lots of time goes in the repair of robots used by us or others'.*

Interest in STEM subjects and career options

All teachers (N=3) believed that the students were interested in programming due to their interest in STEM subjects and all teachers believed that these students will pursue and excel in careers in Engineering or Computer science or any others that involves systems.

4.3 Summarized Observation Notes

Primary School

The observations revealed that all the primary students were enthusiastic about the Robotics lessons and interested to work with robots. The teacher began every lesson with the testing of prior knowledge. Then the teacher moved on to a new topic and explained the concepts with real life connections to the topic. The Arab and Emirati students did not seem to relate as much as the Asian students. The teacher, then modeled the day's tasks detailing the connections and program steps. After, the students were divided into groups and given a robot per group, to do the task by themselves. The graphical interface allowed the students to drag the blocks to form the program. The teacher moved around from group to group to facilitate. The students were told to test their robots and call upon the teacher to display their completed tasks. The teacher had to move between groups and occasionally to the testing table as well. Some groups that had technical or programming problems got tired of waiting for the teacher to respond and started to engage in other activities. The teacher then called everyone to test their robots after a period of time and assisted the ones that did not complete. After the students were told to keep the robots back in their place, the teacher asked all the students to get back to their seats and questioned them regarding the problems they faced during the programming or testing. The teacher gave reasons for the problems and concluded the lesson reiterating the concepts of the day.

Table 1a Class Observation - Primary

Time Allocated for Each Category per lesson in Percentage	
Categories of focus	**Mean %***
1. Student Organization	
Whole group listening/interacting to the teacher	68
Students in groups of three or four students working	12
Off task	20
2. Teacher's Role	
Directing	31
Interactive direction with whole group	21
Modeling whole group	16
Facilitating/Coaching	12
Managing class (off task time)	20

*All percentages are rounded to whole numbers

Secondary School

All the students were keen to enter the lab, in spite of it being an after school activity. Evry lesson, the teacher explained the specific segment of the competition task to be completed. The students were given the parameters and a robot per group to complete the task. The teacher moved to facilitate the groups present in the lab. Students had only two laptops with the software to program. The students took turns to design and program. All students were engaged in the programming and occasional testing of the robot. When the robots did not work according to the program, the students discussed at the testing table itself and then went back to re-program. When the programs worked, the teacher asked them to re-program to make it faster or more accurate depending upon the competition rules. The teacher moved around to each group and questioned the students in the group about their program. Occasionally the groups called upon the teacher when they had a problem. The teacher also used to take some time to find the problem and the solution; sometimes even she could not, she used to ask the students to think over it during the day. The students were reluctant to leave always when the teacher tells them to wind up. The students usually left the lab discussing the program.

Table 1 b Class Observation - Secondary

Time Allocated for Each Category in Percentage	
Categories of focus	**Mean %***
1. Student Organization	
Whole group listening/interacting to the teacher	36
Students in groups of three or four students working	61
Non instruction time	3
2. Teacher's Role	
Directing	12
Interactive direction with whole group	10
Modeling whole group	14
Facilitating/Coaching	61
Managing class	3

*All percentages are rounded to whole numbers

Chapter FIVE

DISCUSSION

5.1 How do Primary School students perceive using robots to learn programming?

Interest, engagement and motivation

Mostly all the students who participated were interested in the robotics lessons. Most even liked it better than their normal ICT skills lessons and claimed they were upset to leave robotics lessons. These results are in line with Maud (2008) who had stated that students enjoy working more with animated tangible products than just adding to their knowledge tank; and compared robotics to a video game that comes to life, thereby exciting them. Students could see instantly if their programs were working or not, which allowed them to play with many parameters and options to see the effects on the solutions. However, it was noted that the Arab and Emirati students did not connect as much as the Asian students. This may be due to the fact that they do not have female role models in their families in the field of engineering and technology and therefore cannot identify the relevance of this subject in their lives (Vidican, 2011).

Connections and Real Life Problems

The students liked the subjects Maths and Science and 50% claim they connected the robotics activities to these subjects. It was evident from the observations that the teacher did not do much to connect the activities to these subjects or even to real life problems. The interviews and the questionnaires confirmed that teachers did not as they needed large amounts of time to prepare and find real life connections to these activities. Kramaski, Mevarech and Arami (2002) had informed that teachers found authentic tasks lengthy and the related assessment difficult and added that this required good support from the curriculum and educational tools. This also confirms studies mentioned in the literature review (Norton, McRobbie & Ginns 2003; Carbone et al n.d.) which stated that the programming feature overshadows connections of Maths and Science with the mechanical components. Also, Palumbo (1990) had stated that young students do not possess the prerequisite skills to form these connections.

Meta-cognition

A substantial number of students did not identify the meta-cognition skills associated with Robotics claimed by Papert (1991). The review of literature has already discussed the significance of meta-cognition in learning and learning to program. A possible reason, according to Schraw (1998) for the lack of meta-cognitive understanding, is that the teacher did not model her own meta-cognition while modelling the working of the robots. Another possible reason is that students did not get enough time to work with the robots themselves (see Chart 2a). Most of the lesson time involved the students listening to or interacting with the teacher, watching the teacher model working of the robots, group discussion and off task time. Children must spend considerable time engaging in independent problem solving where they build their own schemata which requires self initiation and higher level thinking (Simon 1980, cited in Clements & Nastasi 1999). Students must be given oppurtunities to plan and experiment themselves in order to construct meta-cognitive skills (Carbone et al n.d.).

Reflection

A great percentage of students admitted to not reflecting or even thinking about their robotics lessons after class, thus confirming Kramaski, Mevarech and Arami, (2002) who claimed that young students find it difficult to monitor and reflect on their learning. Studies (Cocek 2008; Castledine & Chalmers 2011) in the Literature review had stressed the significance of reflection in the process of learning. The teacher had allocated time at the end of the lessons whenever possible to reflect on the problems faced during the processes and encouraged group discussions regarding the same.

Tasks and Critical Thinking Skills

Regarding the teachers, a significant number of students perceived that the tasks were clear and the teacher encouraged critical thinking skills. The observation tells us that many however, found the programming to be frustrating at times. This is in line with the study of flow (Nakamura & Cziksentmihalyi 2002) mentioned in the literature review that students tend to be frustrated if challenges are above their skills. Some students were able to achieve some tasks but failed to do others. Willingham (2007, cited in Cocek 2008) had correctly noted that students cannot think critically in all situations. Also the programming area is very cumulative in nature, such that concepts learnt in one lesson always carry onto others and if students are confused or stuck at a concept it makes it impossible to understand the next (Carbone et al n.d.).

Results showed that a few of student groups went into extended activities after achieving the set tasks for the day. This is in line with Roger and Portsmore (2004) who stated that this was a potent aspect of the LEGO kits which allows students to stay engaged on task even if at different rates and succeed in ways impossible with traditional methods of teaching and materials where students cannot go beyond the textbooks, lecture halls and expectations of the educators. They recommended directing the extensions based on students' interests and curiousity. Maud (2008) in his study also claimed that students may sometimes surprise teachers by moving beyond teacher set limits.

Team Work and Collaboration

With respect to team work and collaboration, it was noted that most students agreed they discussed their plans and programs with each other within the group and sometimes even with other groups. This confirms Beer, Chiel and Drushel (1999) who had acknowledged that robotics cultivate teamwork skills and peer learning. However, not much time was available for this collaborative learning as apparent from observation (Chart 2a).

Problems in the Robotics Lesson

Concerning the problems faced by students in the classrooms, most of them mentioned the chaos in the classroom and the resulting noise disabling the proper working of the sound sensors. The students are used to the traditional classroom organization and find this set up uncomfortable. Some mentioned technical problems such as unstable robots, disappearance of software, low battery and low memory in the brick. Others mentioned lack of time and unavailability of teacher to help. Mosley and Kline (2006) recommended small class sizes divided into groups of four with equipments per group. Time is an important factor in robotics and students need time to practice (Cocek 2008; Jonassen 2000). Cavas et al (2012) asserted that block hours are necessary to complete some robotic assignments. Carbone et al (n.d.) has also mentioned the pressure of time in their study of robotics, stating that students did not usually have enough time to develop an understanding of the concepts. They also mentioned that new technologies in classrooms always bring problems with equipment or software in terms of battery, memory or even network failures. These results are in line with Cuban (2001) who asserted that according to most research the introduction of new technologies in schools have elicited difficulties especially with younger students and with Buckingham (2007) who claimed that the promise of programming mostly weakens due to student difficulties.

5.2 How do Secondary School students perceive robotics to get introduced to engineering and programming careers?

Interest, engagement and motivation

All the students were interested in the robotics lessons. During the tasks, they were all motivated and engaged and they all seemed upset when leaving the lessons. This is in line with studies (American Association of University Women 2000, cited in Rusk et al 2008) that claimed girls may show increased interest in technology when taught in the context of an interesting discipline. This also confirms studies (Rogers & Portsmore 2004) that claimed LEGO products provide hands-on oppurtunities to girls to develop confidence in subjects like Maths and Science. Some students enjoyed programming while others were good at constructing. In this way, robotics provides multiple pathways and entry points for students with diverse interests and learning styles (Rusk et al 2008). This interest and motivation can be attributed to the subject being optional and that they were preparing for competitions.

Meta-cognition

Regarding meta-cognitive skills, the students were not able to explain clearly why they believed they were taught programming in schools, that too, with robots. However, they were able to identify the skills associated with the learning with explicit examples. They students recognized the significance of creative, designing and building skills. However, when asked about the problem solving skills that may be developed with robotics, only one student mentioned that these robots were used to solve real life problems while all others were talking about problem solving within programming. This is, in spite of the fact that the competition theme was related to real life problems and these students were working on projects that will actually benefit the society and were dealing with meaningful authentic tasks. Beer, Chiel and Drushel (1999) believed that students must be taught to solve problems creatively that just learn by rote and the competition tasks were powerful learning tools that make students actively solve problems and reflect on their achievement of goals. However, there is only limited research (Kramaski, Mevarech & Arami 2002) that shows that teachers create authentic learning oppurtunities for the students and encourage them to reflect and relate them to real life problems.

Reflection

All the school students claimed they reflected on their robotics lessons, even with their family and friends. The teachers also spent time at the end of lessons to reflect on the day's concepts. This time for reflection is very important despite curriculum and performance pressures as it will develop into a habit and help in any profession the students may choose (Schraw 1998). Other studies mentioned in the literature review (Pang 2010; Cocek 2008; Castledine & Chalmers 2011) echo the need for reflection to recognise ones strengths and weaknesses so as to be able to assess and modify strategies and thereby, result in successful learning.

Critical Thinking Skills and Tasks

All the students perceived that the teachers encouraged critically thinking skills which they recognized as a vital skill during competitions to enable them to solve problems on the spot. All the students also perceived that the lessons were structured and tasks were clear. Tasks must be designed that require students to contemplate, discuss and evaluate own learning. Research (Carbone et al n.d.) showed that tasks can impact meta-cognition; and with the understanding of students' learning situations, guidelines can be formulated to design programming tasks to direct learning behaviours of students. Other research (Cocek 2008; Jonassen 2000) agreed that it is a must that critical thinking lessons be modeled, shared, instructed and integrated throughout the students' schooling; and (Clements & Nastasi 1999) confirmed that appropriately designed programming environments positively impact student meta-cognition.

Team Work and Collaboration

The students mentioned that they always discussed amongst themselves the building designs as well as the programming aspects when working on projects and also with other groups when they encountered problems. This indicates that they recognised the significance of team work and collaboration in competitions in order to come up with quick and varied solutions together. This is in line with studies mentioned earlier (Korcshnoy &

Verner 2010) which stated that collaboration with own and other groups immensely improve the robotics learning experience.

Problems in the Robotics Lesson

Regarding the problems in the robotics lessons, students perceived lack of time, lack of laptops or dedicated labs as the main issues that needed to be resolved. Carbone et al (n.d.) agreed that mostly students find difficulty in managing time when technical problems arise or tasks are too demanding and Rogers and Portsmore (2004) advised the need for continuous blocks of time to engage in critical thinking and problem solving. Mosley and Kline (2006) in their study has suggested 4.5 hours to complete assignments adding that time to experiment was vital for understanding. They also recommended a dedicated classroom with open space for testing the robots.

Career choices of the Secondary Students

Most of the students started thinking about careers in Engineering or Computer Science after training in robotics. This confirms the growing research studies that claim robotics inspire students to pursue careers in STEM (Hendricks, Alemdar & Ogletree 2012; Brand, Collver & Kasarda 2008). Other studies (Papert 1980; Rogers & Portsmore 2004) had pointed out that robotics enable learning of many disciplines together and Barker and Ansorge (2007) had asserted that with robotics, students learn to create complex systems with parts that depend on one another which are useful in most professions that need to understand the same.

5.3 How do Teachers perceive using robots as an educational tool to teach programming?

Primary School Teachers

Student Skills and Connections

The primary teachers believed that the robots enhanced many skills in the students such as motor skills, time management skills, creative skills, ICT skills, problem solving and designing skills. The teachers also appreciated the logical thinking skills, critical thinking skills, team spirit, social and collaboration skills that were implicitly developed. Teachers believed that the students developed meta-cognitive skills as they were 'learning to learn' unknowingly.

This is in conjunction with studies (Korcshnoy & Verner 2010; Maud 2008) which stated that the robotic environments enable students to gain the knowledge and skills to achieve the goals as they are involved in the process and understand the concepts without even realising. The teachers perceived the students as engaged and motivated in the robotics lessons but did not see students form any connections to subjects such as Maths and Science. They admitted that they did not have the time to make these connections in the classrooms as they were busy with teaching the programming concepts, thereby reconfirming the study by Carbone et al (n.d.) mentioned earlier. Occasionally some students achieved more than what was expected of them as mentioned in previous studies (Norton, McRobbie & Ginns 2003). Teachers were not prepared for variability in terms of time or tasks causing some students to be uninterested and disruptive. When these students felt tasks were beyond their capacity it left them frustrated. This is in line with studies (Mosley & Kline 2003) that stated robotics provides learning for all but teachers must develop strategies that encourage students to reflect from experiences and not just surface learning experiences (Carbone et al n.d.). Chambers Carbonaro and Murray (2008) echoed the need for teachers to prepare for variability in their study.

Problems in the classroom

Teachers perceived that few students in every class were disinterested and could not follow the lessons. These students caused management problems in the class. Teachers also mentioned need for time, open space and adult support to take care of these as well as the technical problems during the lessons. This confirms studies (Beals & Bers 2006) that stated problems were not always due to the technology itself or the teacher or the students but due to the logistical setups with one teacher per twenty students working in short blocks of time. All teachers were satisfied in terms number of robots, software and laptops.

Teacher perceptions of robotics lessons and of students' perceptions

All the teachers claimed that they enjoyed teaching with robots compared to the ICT classes. All the teachers also believed that robots were valuable teaching tools as they were hands-on material providing motivation for the students and enhancing many skills in them. Mostly all the teachers were confident to handle robotics lessons as much as they were to take ICT lessons. They also perceived they did a satisfying job in the robotics lessons. However, they believed that the curriculum must not do away with ICT skills altogether as they believed these skills were necessary on a daily basis. This is in line with a comment in an article (Curtis 2012) that stated ICT office skills were necessary in the workforce.

All teachers believed that most students were interested and all were engaged especially when they were hands on with the robots. They reasoned that the students were interested because it was a new concept which challenged them and enabled them to participate actively. They understood that for some students the competition aspect between groups was attractive while for others it was the simple achievement of tasks. They also believed that programming was not appealing to all students as was evident during the observations. Some students did not have the skills associated with it and others merely saw the robots as toys. This contradicts Papert's constructionist theory (Bers et al 2002) which claimed that all students will be engaged in learning if they are constructing meaningful artefacts.

Lesson structure and Teacher roles in a robotics lesson

The lessons involved long recapture sessions in the beginning as most of the times, students forgot concepts taught previously and needed to be reminded to move on to the next concept. These sessions were followed by in depth explanations of the new concept and task and modeling of the same. This confirms Palumbo's (1990) study mentioned in the literature review where he claimed that primary students may not have the pre-requisite skills for programming. The student-centered programming and testing phase which followed was very short in comparison to the directing, modeling and interacting phases. Teachers tend to clarify aspects of the mechanical tools and connections (Buckingham 2007) to the students rather than focus on the critical thinking or programming logic features, thereby spending a lot of time in instructing and directing. The teachers mostly assumed the roles of a director and a mediator but was a facilitator for a very short while

All teachers perceived the need for training to teach with robots. The significance of cautious scaffolding for students to connect their understanding to authentic settings was mentioned in the literature review (Castledine & Chalmers 2011). However, Beals and Bers (2006) questions the capacity of teachers who are learning nothing new themselves to judge the Zone of Proximal Development (ZPD) of their students and their ability to provide a better learning experience. The teachers need to be pedagogically trained to guide the students.

Other suggestions made by the teachers include small class sizes, open testing space, preparation time, time in classrooms for repairs of robots in addition to time for students to think and experiment, as well as adult support. These will be discussed further in the recommendations chapter.

Secondary School Teachers

Student Skills

All teachers perceived robots to be powerful teaching tools as they develop skills such as creative skills, critical thinking skills, logical thinking skills, problem solving skills, designing and collaborative learning skills in addition to enhancing motivation and engagement in students.

Problems in the Robotics lessons

Teachers perceived lack of resources, time, space and technical support as the main problems in the robotics lessons. Again this is in agreement with studies mentioned earlier.

Teacher feelings

All the teachers claimed they enjoyed teaching robotics lessons compared to the ICT classes. The teachers seemed just as confident in their robotics lessons compared to their ICT lessons and they seemed satisfied with their robotics lessons. It can be noted that the secondary students as well as the teachers perceived the robotics lessons positively which confirms studies (Bandura 1977; Korschnoy & Verner 2008) that told teacher attitudes and beliefs greatly influence classroom atmosphere and the self confidence of students. All the teachers welcomed the recent changes in the UK ICT curriculum that decided to introduce programming in schools but added it must be an optional subject in the curriculum.

Teachers' perceptions of students' perceptions

All teachers believed the students were very interested in the robotics lessons and engaged throughout. They perceived the students to be motivated as they were here by their own choice and this also resulted in them being creative. By taking the decision to choose a creative subject, students strive hard to be creative in it (Sternberg 2001 cited in Pike 2003).

Teachers’ roles and Lesson structure

The teachers perceived themselves as facilitators just explaining the task once and then letting the students discover for themselves. This was confirmed in the observations (Chart 2b). Teachers encouraged critical thinking as well as cooperative learning skills. The secondary teachers could afford to facilitate more than the primary teachers. Secondary students did not need much time for recapture of previous concepts and also the explanation of new concepts and tasks did not take long as compared to the primary students.

The lesson structure involved more time for student programming and testing than for lecture and discussion. Concepts were reinforced at the end of every lesson. Teachers did not feel the need to prepare for variability as all students had high aptitude as well as attitude. This confirms the study by Ahmed and Aziz (2009) which stated that teachers make classroom decisions based on stimuli from students.

Teacher needs

All teachers perceived the need for training to teach programming with robots. Cope and Ward (2002) had stressed the significance of professional development, even for experienced teachers in the use of learning technologies to enhance learning outcomes in students. Teachers also demanded more resources, space and time for teachers and students. Earlier studies (Cocek 2008; Jonassen 2000) had noted the extra time needed by the teachers for adequate preparation. Open labs, abundant robots, small class size and groups were listed as essential criteria to create a favourable environment with students reporting the need for sufficient time to experiment with many trial and error sequences to program the robot to move or turn in precise paths (Mosley & Kline 2006).These will be discussed in detail in the recommendations chapter.

Interest in STEM subjects and career options

The teachers perceived the students’ ability to perform well in Robotics was due to their interest in the STEM subjects and their exposure to robotics will encourage them to develop further in these fields. This is in conjunction with studies (Rockland et al 2010) that claim that such subjects must be introduced in the K-12 curriculum so as to get students into the mindset of considering Engineering or other Science fields as their career possibilities.

Chapter SIX

LIMITATIONS AND RECOMMENDATIONS

6.1 Limitations

Most studies have limitations that may have affected their results. They are the weaknesses identified by researchers which may be useful to potential researchers who may want to replicate the study and to readers to judge the generalisability of the study to other people or situations (Creswell 2008). This research study too has a few limitations.

1. One of them is that the data sources are self reports. This is an evident limitation especially in the case of primary students where some of the questionnaire responses and the interview excerpts did not coordinate with the observation notes. However, accuracy had been attempted with triangulation and in the next study the questions in the questionnaires and interviews can be chosen carefully to gather more accurate responses.

2. Another limitation includes the sample selection being only girls which does not allow the results to be generalised for boys. Rusk et al (2008) asserted that boys may be able to integrate LEGO materials and programming more creatively due to their familiarity with the same. Even the teachers selected were females and results may differ with males.

3. Also, Vidican (2011) discovered that very few women from UAE and the Middle East are working in the field of Science and Technology in comparison to males, so the girls may not see any relevance in learning to program. Their counterparts from other parts of Asia may have female role models in the family which allow them to appreciate the subject differently. For this reason, the reluctance to engage may not be generalised beyond this geographical area. Also, the situation may change in time.

4. It was noted in this study that the secondary school students who opted for the robotics lessons were interested tremendously in the competition aspect. Rusk et al (2008) had asserted that while competitions may be interesting to some, it may be alienating for others. They suggested exhibitions are better to attract all students. A study with students participating in exhibitions may reveal different results.

5. Another limitation was the sample size of teachers which is low (only 6) and results may vary with a larger number of participants.

6.2 Recommendations for Improvement after Present Study

1. From the current study students and teachers echoed the need for more time to practise and think. Therefore, arrangements must be made to have block hours together so that students get uninterrupted hours with robots and programming. Also, time for preparation for the teachers as well as time in the class for repair of robots or other technical problems must be considered.

2. Another issue that kept coming up was the need for dedicated robotics labs and open spaces. This is essential for storage and security of software as well as for testing the robots.

3. Small class sizes are recommended so that the teachers can be available to attend to all the groups to facilitate and guide their thought processes. Chambers, Carbonaro and Murray (2008) have stressed in their study that timely intervention from the teachers or scaffolding, is very important to develop understanding of complicated concepts.

4. Lab assistants are necessary to help with the technical issues so that teachers do not have to waste time fixing the robots, changing batteries, checking faulty programs or crashed laptops when they should be mentoring the students. Rogers and Portsmore (2004) asserted that teachers must be available to ask insightful questions and start discussions to actually improve student learning.

5. Teachers in the current study have not been trained to teach with robots. This means that they have not received any pedagogical training as to how to use robots to teach programming. It is imperative that they be guided properly for successful implementation of these tools in the classroom. Beneficial information to educators and curriculum advisers are available at the LEGO website (www.legoengineering.com) concerning curriculum, activities and resources but teachers must also have regular workshops and training sessions about the latest developments in robotics.

6. From the study as well as the comments from teachers, it appears that programming capability may not be there in all students. Therefore, robotics must be offered as an optional subject or tasks must be such that students take up the aspect they are

interested in, be it programming or constructing and they must be assessed, if at all, based on those chosen aspects.

7. An important recommendation would be to design tasks to significantly relate to authentic settings in the community where student IT competency can be improved as well as the interest of student and community served. This will instil a sense of satisfaction in them to be able to apply one's skills to improve community and society. If the learner has attitudes and perceptions contributing to learning and if he is trained to use his mind effectively, he will strive to acquire and integrate new knowledge always and with time he will develop a habit to extend and refine his current knowledge. The ideal goal of education must be to enable him to use this knowledge in significant and meaningful ways (Marzano 1992).

6.3 Recommendations for Future Research

1. Since the school had just introduced robotics as a part of its curriculum both teachers as well as students were new to the concept. It may take years for the students to acquire certain skills that come only with practice or development. A longitudinal study may be useful to explore how students develop these skills over time; and may yield different results. Also such a study will tell us what support the students need to develop these skills.

2. As noted in this study and previous studies (Chambers, Carbonaro & Murray 2008; Castledine & Chalmers 2011) mentioned in the literature review, scaffolding plays a big role in the introduction of any technology in classrooms, thereby further research into appropriate pedagogies for scaffolding in robotics lessons is also necessary.

3. Since the primary goal of robotics is to engage students in authentic situational learning, research is also needed to find strategies to combine real world contexts with successful robotics lessons.

4. In this study it was noted that teachers declared that they did not prepare for variability in students even though previous research (Mosley & Kline 2003) in robotics asserted that it caters to learners of all abilities. Research is required to develop strategies that may benefit students with different abilities.

5. Lastly, research is required to develop efficient training strategies for facilitators.

Chapter SEVEN

CONCLUSION

This study aimed to explore the perceptions of primary and secondary female students as well as those of teachers regarding the use of robots to learn programming in a private school in Abu Dhabi. A pilot of the study was conducted previously on the middle school students of the same school. Qualitative methods of data collection were employed to capture subjective information, which is ideal to understand the perceptions, attitudes and experiences of students and teachers when working with robots. Countries around the world such as, the U.S. and U.K. are planning to change their ICT curriculums from ICT skills to programming, to prepare their students for a high tech economy. Many UAE schools follow these curriculums and have decided to do the same. Hence, it is vital to study the perceptions of the most important stakeholders namely the teachers and the students, who are directly involved with the teaching and learning of robotics in schools for the successful implementation of robotics.

Data from the questionnaires, interviews and observations indicated that most primary students were highly motivated to work with robots as it provided hands-on and creative tasks. Many skills such as problem solving, designing, and collaborative skills were developed on a small scale. The study however, reported that no connections to subjects such as Maths and Science were made or even to real life situations. Students were unable to identify the meta-cognitive skills involved and they also admitted to no reflection on their learning. Some students were frustrated, few achieved the tasks and very few went ahead to extended activities. Problems in the classrooms included lack of time, open space and teacher unavailability. The study informed the need for varied tasks to keep all the primary students at task during the lesson; strategies to encourage meta-cognitive and reflective skills to enhance the learning experience; and resources such as blocks of continuous time, dedicated labs with open spaces and adult support in the class to take care of technical issues while the teacher focuses on facilitating and scaffolding.

In the secondary school, all students were found to be motivated, interested and engaged during the lessons. This was attributed to the subject being an optional course to participate in competitions. Most of students could not identify the meta-cognitive skills associated with the learning of programming and learning with robots. However when provided with specific skills they were able to provide explicit examples. Critical thinking skills and collaborative skills were perceived in the lessons and considered vital by the students for the competitions. The students reflected upon their learning but most could not relate their learning to real life problems in spite of the competition tasks being concerned with authentic real world problems. Problems such as lack of resources and dedicated labs with open spaces were brought to light with this study. The robotics lessons appeared to have influenced the decisions of some students to pursue careers in Engineering and Computer Science.

The primary teachers agreed that robots to be valuable educational tools as learning to program with them enhanced many skills in the students such as creative, problem solving, and collaborative skills. They believed the students also developed meta-cognitive skills unknowingly and that all students were motivated and engaged, it being a hands-on and creative subject. They added that all students are not capable of programming. They admitted not having the time for connections to Maths and Science subjects and to real life situations; and also to prepare for variability in the class. The teachers enjoyed teaching with the robots but they perceived some difficulties in its successful implementation. They stated that much time was needed to explain the concepts to the young students regarding the mechanical tools and connections. They also stated the need for pedagogical training, smaller class sizes, space, time and adult support in the class.

The secondary teachers also believed robotics enhanced the creative, critical thinking, logical thinking, problem solving designing and collaborative skills in the students. The perceived all the students were motivated and engaged as they opted for the subject to participate in the competitions. The teachers claimed they enjoyed teaching robotics and were confident and satisfied with the lessons. They perceived themselves as facilitators as they were mostly guiding the students. They did not need much time to explain the concepts or tasks to the secondary students and they claimed those who joined the course were proficient in the STEM subjects and would only develop in them further. They looked forward to the new ICT curriculum but added that robotics will succeed only as an optional subject. They also put in the need for more time, space, adult support and resources in addition to pedagogical training.

Although this study reported advantages in students' attitudes and motivation toward Science and technology, some findings identified problems in the use of robots to learn programming. This is in line with previous studies (Rusk et al 2008) that claim robotics present powerful educational oppurtunities but these activities are limited by the restricted ways in which it is introduced. This study contributed significantly to providing insights to the educators and schools for improved implementation. It also suggested future research to develop strategies and resources for better practices; a longitudinal study and a comparative research in the boy's school or with male teachers.

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APPENDIX A

<u>Questionnaire for **Primary Students**</u>

I am currently pursuing my Masters in Education specializing in ICT and for the purpose of my dissertation I am looking at students' and teachers' perceptions of Robots as a resource for teaching and learning within UAE and would value your thoughts, experiences and opinions on this matter. Your help in assisting me gather data to comment on the subject is very much appreciated.

The questionnaire will only take approximately 10 minutes of your time to complete.

Your participation in this project is completely voluntary and you are free to decline the invitation to participate, without consequence, at any time prior to or at any point during the activity. Any information you provide will be kept confidential and used only for the purposes of this study and will not be used in any way to reveal your identity. All questionnaire responses, notes and records will be kept in a secured environment.

Many thanks for your assistance,
Shehla Arif

<u>Information about your Robotic programming classes:</u>

1. Do you like the subjects Maths and Science?

YES	NO

2. Do you look forward to your robotics classes?

I hate it	I don't care	It's my favorite class

3. Why do you think you are learning to program with robots?

………

………

………

………

4. What skills do you believe you are learning in robotics class? (You may select more than one**[X]** but please provide examples to be clear)

   a. To be creative ☐ Example:……………………………………………………………………..
   b. To learn to think ☐ Example:……………………………………………………………………..
   c. To learn to solve problems ☐ Example:……………………………………………………………………..
   d. To learn to build ☐ Example:……………………………………………………………………..
   e. General computer skills ☐ Example:……………………………………………………………………..
   f. Others, please specify with example : ………………………………………………………………………………

5. When you are working with robots do you feel

Bored	Interested	Frustrated

6. When you are in the robotics class do you feel you are

Only Playing	Playing and Learning	Only learning

7. How clearly are activities explained to you by you teacher?

I don't have a clue	Just about OK	Very well explained

8. Does your teacher ask you to think when there is a problem (or does she just tell you what to do)?

Always	Sometimes	Never

9. What problems according to you, are there in the robotic classes?

   a. Classroom control ☐ Example:…………………………………………………………………….

   b. Few robots ☐ Example:…………………………………………………………………….

   c. Teacher issues ☐ Example:…………………………………………………………………….

   d. Lab too small ☐ Example:…………………………………………………………………….

   e. Others ☐ Please specify with example:…………………………………………………………………….

10. Does your group try to solve by yourselves if you have a problem or do you just go to the teacher?

Always	Sometimes	Never

11. Do you discuss with your friends in other groups during class?

Always	Sometimes	Never

12. How do you feel when you are done with your robotics class?

Happy to leave	I don't care	Very upset to leave

13. Do you think about the activities you did in the robotics class after it is over?

Always	Sometimes	Never

14. Do you understand Maths and Science better after you have learnt to program with robots?

…….

…….

APPENDIX B

<u>Questionnaire for **Secondary Students**</u>

I am currently pursuing my Masters in Education specializing in ICT and for the purpose of my dissertation I am looking at students' and teachers' perceptions of Robots as a resource for teaching and learning within UAE and would value your thoughts, experiences and opinions on this matter. Your help in assisting me gather data to comment on the subject is very much appreciated.

The questionnaire will only take approximately 10 minutes of your time to complete.

Your participation in this project is completely voluntary and you are free to decline the invitation to participate, without consequence, at any time prior to or at any point during the activity. Any information you provide will be kept confidential and used only for the purposes of this study and will not be used in any way to reveal your identity. All questionnaire responses, notes and records will be kept in a secured environment.

Many thanks for your assistance,
Shehla Arif

<u>Information about your Robotic programming classes:</u>

15. What subjects have you chosen for your O levels/ what career do you choose to pursue?

…………………………………………………………………………………………………/…………………………………………

16. Do you look forward to your robotics classes?

I don't care about it	I don't like it	I like it	I like it a little	It's my favorite class

17. Do you understand why you are learning to program? If Yes, why?

………

………..

And why with robots?………

………..

18. When you are working with robots do you feel

Bored	Slightly bored	Engaged/Involved	Slightly frustrated	Frustrated

19. What skills do you believe you are learning in robotics class? (You may select more than one **[X]** but please provide examples for clarification)

   g. Creative ☐ Example:………………………………………………………………………………

   h. Critical thinking ☐ Example:………………………………………………………………………………

   i. Problem solving ☐ Example:………………………………………………………………………………

   j. Designing ☐ Example:………………………………………………………………………………

   k. Constructing ☐ Example:………………………………………………………………………………

   l. ICT skills ☐ Example:………………………………………………………………………………

   m. Others , please specify with example : ………………………………………………………………………

20. When you are in the robotics class do you feel you are

Only Playing	More playing Less Learning	Playing and Learning	Less playing More Learning	Only learning

21. How clearly are concepts and tasks presented to you by you teacher?

I don't have a clue	I understand very few things	Fairly structured	I have very few doubts	Very well structured

22. Does your teacher ask you to think or does she tell you what to do?

Always	Most of the time	Sometimes	Never	I don't care

23. Do you plan before you construct and program?

Always	Most of the time	Sometimes	Never	I don't care

24. What problems according to you, are there in the robotic classes?

   f. Classroom management ☐ Example:……………………………………………………………….

   g. Few resources ☐ Example:……………………………………………………………….

   h. Teacher issues ☐ Example:……………………………………………………………….

   i. Lab too small ☐ Example:……………………………………………………………….

   j. Others ☐ Please specify with example:……………………………………………………………….

25. Does your group try to solve by yourselves if you have a problem or do you just go to the teacher?

Always	Most of the time	Sometimes	Never	I don't care

26. Do you discuss with your friends in other groups during class?

Always	Most of the time	Sometimes	Never	I don't care

27. How do you feel when you are done with your robotics class?

Relieved	Slightly relieved	No feelings	Slightly upset to leave	Very upset to leave

28. Do you think about the activities you did in the robotics class after it is over?

Always	Most of the time	Sometimes	Never	I don't care

APPENDIX C

<u>Questionnaire for **Teachers**</u>

I am currently pursuing my Masters in Education specializing in ICT and for the purpose of my dissertation I am looking at students' and teachers' perceptions of Robots as resource for teaching and learning within UAE and would value your thoughts, experiences and opinions on this matter. Your help in assisting me gather data to comment on the subject is very much appreciated.

The questionnaire will only take approximately 15 minutes of your time to complete.

Your participation in this project is completely voluntary and you are free to decline the invitation to participate, without consequence, at any time prior to or at any point during the activity. Any information you provide will be kept confidential and used only for the purposes of this study and will not be used in any way to reveal your identity. All questionnaire responses, notes and records will be kept in a secured environment.

Many thanks for your assistance,

Shehla Arif

A - Some demographic information

1. How many years of teaching experience?

< 2 years	2-5 years	5-8 years	8-11 years	>11 years

2. Are you ICDL certified? (Please select one box [X])

YES	NO

3. Do you have an internationally recognized teaching qualification for the subject that you are currently teaching? (Please select one box [X])

YES	NO

4. What is your highest 'completed' qualification you currently hold? (Please select one box [X])

High school diploma	Bachelors	Masters	EdD	PhD

B – Information regarding Robotic Programming lessons

In this section, I would like you to discuss your perceptions and attitudes before, during and after your Robotic programming lessons. Please be as honest as possible, remember **this is not a test** but an attempt to find out more about teachers and their perceptions about robotic programming as a valuable educational tool. If you have any questions please call the person in charge over.

5. How many hours of preparation are necessary to take a Robotics class?

1-2 hours	2-3 hours	3-4 hours	4-5 hours	>5 hours

6. Do you believe that robots are a valuable educational tool? (Please select one box [X])

YES	NO

Why?

……

……

……

7. What skills according to you, can Robotic programming teach the students? (You can select more than one[X]).

Creative	Critical thinking	Problem solving	Designing	ICT	Others Please specify

8. What kind of positive issues are there in a robotics class compared to other ICT classes you teach? (You can select more than one[X]).

Students motivated	Students engaged	Students manageable	Good group dynamics	Others please specify

9. What kind of problematic issues do you have in your robotics class?

   (You can select more than one[X]). Please explain further.

Classroom management	Few resources	Students uninterested	Lab too small	Others please specify

……………………. …………………… ……………………. ………………….. …………………….

……………………. …………………… ……………………. ………………….. …………………….

10. How confident do you feel before every robotics class compared to the other ICT classes you teach?

Completely nervous	Slightly nervous	Slightly confident	Confident	Very confident

11. How confident are you in the general ICT classes that you teach?

Completely nervous	Slightly nervous	Slightly confident	Confident	Very confident

12. What do you think of the students' attitudes to robotics classes before they start?

Not at all interested	Slightly interested	Interested	Very interested	Extremely interested

13. How confident do you feel during the class?

Completely nervous	Slightly nervous	Slightly confident	Confident	Very confident

14. How do you feel after the class is over?

Relieved	Slightly relieved	Satisfied	Quite satisfied	Very satisfied

15. What are the students' attitudes after they are done?

Relieved	Slightly relieved	No feelings	Slightly upset to leave	Very upset to leave

16. Do you have sufficient resources?

More than enough	Sufficient	Can do with more	Very few	Don't have any

17. How do you feel your role as a teacher has changed from when taking a robotics class?

No change in role	More lecturing	Lecturing and facilitating	Facilitating	Lecturing, facilitating & lab assistant	Others Please specify

18. What do you do when your students are faced with difficulties in class?

Ask them to solve themselves before helping	Ask them to discuss with their peers	Go to them without them calling	Refuse to help at all	Ignore	Others Please specify

19. How is student behaviour in the robotics lesson?

Chaotic until tasks given	Chaotic throughout	Engaged for a while	Engaged the entire class	Others Please specify

20. Did you receive training as to how to teach programming with robots?

YES	NO

21. Would you like to receive training on how to teach programming with robots?

YES	NO

22. Do you believe students are 'learning to learn' in a robotics programming class?

YES	NO

Any comments?..

……….

23. For primary school teachers only:
Do you believe students are likely to understand Maths and Science concepts better as they are introduced to programming with robots?

YES	NO

Any comments?..

……….

24. For secondary school teachers only:

    a. Do you believe that your students excel in programming as they have chosen Science or Maths for their O levels (positive aptitude and attitude towards these subjects)?

YES	NO

Any comments?..

    b. Do you think your students may choose engineering or programming careers as they are introduced to Programming with robots in high school?

YES	NO

Any comments?..

APPENDIX D

Interview Questions for Students – **Primary Students**

1. Do you like Maths and Science subjects?
2. Do you enjoy Robotics lessons more or ICT lessons?
3. Do you like programming or building the robots?
4. Are the tasks clear to you always?
5. Does the teacher ask you to think or just tell you the code?
6. Do you discuss with your friends in your group
7. Do you have any problems in the robotics lessons? If yes, please tell me what kind of problems
8. Do you think about your robotics lessons after the classes?

APPENDIX E

Interview Questions - **<u>Secondary Students</u>**

1. Do you enjoy Robotics lessons?
2. Can you connect Robotics to your Science or Maths subjects?
3. What careers are you interested to pursue? If Engineering or Computer Science, did you get interested after attending the Robotics lessons?
4. Are you interested in the building or the programming aspect of robotics?
5. Are the tasks clear to you always?
6. Do teachers encourage you to think, discuss and solve problems yourselves or do they just tell you the code?
7. Do you discuss with your group members?
8. Do you discuss with other groups?
9. Do you have any problems in your labs? If yes, please elaborate
10. Any comments or suggestions you would like to make?
11. Do both your parents work?
12. What is your nationality?

APPENDIX F

Interview Questions for **<u>Teachers</u>**

1. Do you like teaching with robots?
2. The UK government has decided to change the ICT curriculum from teaching of IT literacy and skills to programming. What is your opinion regarding this?
3. What according to you are the advantages of teaching programming with robots?
4. What according to you are the disadvantages of teaching programming with robots?
5. What problems do you face in your Robotics lessons?
6. Do you believe that Robotics classes enhance any skills in your students? If yes, what skills?
7. What do you believe are students' feelings when they learn programming with robots?
8. How do you structure your Robotics lessons?
9. Do you believe you encourage critical thinking skills? If yes, how?
10. Do you come prepared for variability in your class during Robotics?
11. What is the role you assume in your Robotics classroom?
12. Any suggestions for improvement?

APPENDIX G

Observation Sheet – **Primary and Secondary Students**

Time Intervals	Roles and Organisations	Reflections
00 -10 minutes	Teacher: Student: Class organization:	
10 - 20 minutes	Teacher: Student: Class organization:	
20 - 30 minutes	Teacher: Student: Class organization:	
30 - 40 minutes	Teacher: Student: Class organization:	
40 - 50 minutes	Teacher: Student: Class organization:	
50 - 60 minutes	Teacher: Student: Class organization:	
60 - 70 minutes	Teacher: Student: Class organization:	
70 - 80 minutes	Teacher: Student: Class organization:	

APPENDIX H

Pilot Study – Middle school students

MASTERS IN EDUCATION

EDU515

E-LEARNING AND BLENDED LEARNING

Students' and Teachers' Perceptions of Learning to Program with Robots in a Private School in Abu Dhabi

Module Coordinator: Dr. Naz Awan

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TABLE OF CONTENTS

INTRODUCTION

Technology is an integral part of schooling now. The current ICT curriculum in the United Kingdom (UK) emphasises the teaching of IT skills, considered critical for future workplace scenarios. New developments, however, inform us that programming is going to find its place again into the UK curriculum. Programming is the process of writing a set of instructions that computers need to complete tasks (Palumbo, 1990). Programming, in the 1980s, was believed to create a highly responsive learning environment where students could learn themselves to become systematic and organised problem solvers (Mayer, 1988). Seymour Papert (1980) was a pioneer who advocated for programming as a worthwhile domain in education claiming the benefits of its discovery approach and also in its potential to get the students to learn how to think. However, many teachers used LOGO; a programming language developed by Papert for young children, in classrooms and ended up with mixed results (Dennett, 1993). Ultimately, with the disappointing reality of students' difficulties and no transfer of skills, the radical promise of LOGO faded out (Buckingham, 2007). LOGO has since teamed up with the plastic building blocks company LEGO, and created a new trend of enjoyable arenas for learning (Dennett, 1993) and thereby 'robots arrived at the doorstep of education' (Barker & Ansorge, p.39) providing children with the opportunity to design, construct and program (Carbonaro et al., 2008). This supported National Research Council (1996) that called students to actively engage in problem solving by designing, constructing, analyzing, and proposing solutions to situations outside classrooms.

As mentioned earlier, the popularity of programming has gained momentum in the field of education once again. The UK Education Secretary recently announced that the current ICT curriculum will be replaced with a flexible one in Computer Science and Programming, designed with the help of universities and industry (Burns in BBC, 2012). To study the perceptions of the students and teachers involved would be relevant at this point as they are going to be directly impacted by this change in the curriculum. Perceptions are very important in education just like in all other areas of human activity, due to its strong influence on well being and behaviour. Students' perceptions of their educational experiences like school events, teacher expectations, and teacher-student interactions impact their academic achievement (Siegle & Reis, n.d.). Sometimes perceptions may be the exact opposite of what seems to be the situation and thereby it is important to address this issue to assess the quality of any educational implementation.

Keeping in mind that Robotics has become a popular educational activity internationally to teach programming (Rusk et al, 2008) this study proposes to explore the perceptions and attitudes of the students and the teachers involved in the teaching and learning of programming with robots in school.

LITERATURE REVIEW

Papert’s theories rested on his beliefs that children took to technology as ducks to water and that learning must be self-directed, non-verbal, experiential and spontaneous and instead of schools claiming to educate children they must merely create contexts in which children learn (Buckingham, 2007). Dennett (1993) reported that when his ideas were criticised, Papert instantly blamed the schools for incapacitating the students to think and claimed that the standard means of testing cannot be trusted to reveal the anecdotal benefits of his before-and-after comparisons although he agreed that feedback was necessary to steer these experiments in the right direction with no clear statements as to the kind of feedback. Papert (1980) is also credited with the development of Constructionism, based on Piaget’s Constructivist theory where he claims that if students were to construct artefacts that others may see, use or criticise then their involvement in learning will increase. Constructionism emphasises that physical interactions with objects rather that abstract formalisations, constructs knowledge and students using robots as educational tools learn actively by building and actually experiencing the abstract concepts meaningfully in a constructionist environment (Carbonaro et al., 2008). This confirms Papert’s (1980) assertion that programmable robots were flexible yet powerful tools to explain ideas that had no easy real-world analogies. Papert (Barker & Ansorge, 2007) also testified that children could easily relate to robots as they were concrete, physical manifestations of the computer and its programs, thereby the best tools to put the constructivist theory to practice. He collaborated with LEGO, the building blocks company to create the NXT programmable kits which Beals and Bers (2006) claim allow students to explore abstract thoughts, ideas, and designs with concrete materials. Science educators echoed that hands on experiences with manipulatives such as robots used to test abstract design concepts are crucial for the conceptual development of children (Carbonaro et al., 2008; Oddie et al., 2010).

Robotics help children learn about many disciplines such as Science, Engineering, Electronics and Technology, as they learn to engineer robots (Papert, 1980) with the motors, sensors and programs (Barker & Ansorge, 2007) and thereby understand complex systems (Beer et al., 1999). The non-traditional approach of teaching with robots engage students in Science to put fundamentals learned to practice, furthermore, the opportunities to participate in competitions and work with mentors, motivates them and fuels their interest in pursuing careers in the above mentioned disciplines (Brand, Collvers & Kasarda, 2008). Then again, Buckingham (2007) asserts that any kind of motivation seen is only temporary and superficial. Other studies (Barker & Ansorge, 2007) however, inform that not only do they motivate, robotic platforms also encourage problem solving and cooperative learning skills and still others (Beer et al., 1999) reiterate that the problem solving skills derived from designing an entire system to work in real world and the teamwork skills that robotics seemed to foster, are very useful for students' future careers. An interesting study by Rogers and Portsmore (2004) noted that girls enjoy the modelling and deduction aspects of designing and solving problems with robots, relevant to the surrounding world in terms of purpose and meaning.

Despite everything, Buckingham (2007) argues that Papert's influential ideas were based on his small scale research with LOGO programming with young children and his assumptions about childhood, learning, technology and schools which are insufficient to make broader arguments. He also claimed that teachers, in reality used LOGO as enrichment and the students were bored or frustrated and needed support and guidance as opposed to Papert's belief. Palumbo (1990) has explored studies that state that the evidence of effectiveness of programming on the problem solving skills of children is mixed. Also, there is limited evidence that procedural skills claimed to develop with learning programming transfers to other situations (Armstrong & Casement in Buckingham, 2007) while Weizenbaum (Buckingham, 2007) affirms that using computers do not improve children's problem solving skills. Studies have shown that most obstacles may not occur due to limitations of technology, students or teachers alone but because of poor classroom set-ups with one teacher for 20 or more students working in short amounts of time (Rogers and Portsmore, 2004). Spacious labs, ample robots, small class size and small groups were listed as important criteria to create a conducive environment with students reporting the need for ample time to experiment as it may take many trial and error sequences to program the robot to turn or move in specific directions (Mosley and Kline, 2007). Goldenson (1993) reports that programming courses foster higher order thinking skills only if properly conducted and Palumbo (1990) states that if any kind of problem solving transfer is to occur, then careful designing of strategies and adequate time for students to build and use the knowledge is crucial. Dennett (1993) personally attested that LOGO in the right circumstances worked wonders with the children, then again stated that these right circumstances were difficult to come by. In order to take control of their own learning students must question themselves and peers and not immediately seek answers from the teachers (Oddie et al., 2010) and teachers as mentors must engage students by posing questions and encouraging discussions so as to support learning without giving away solutions (Brand, Collvers & Kasarda, 2008). In their study, Barker & Ansorge (2007), teachers asked students questions after they completed the set challenges which helped them reflect and generalise findings and thus were encouraged to transfer the knowledge gained to similar or different situations. However, Buckingham (2007) noted that mostly teachers focussed on the mechanical tools and not the critical thinking aspect. Carbonaro et al. (2008) stated that lesson activities must be thoughtfully constructed to reveal common students pre-conceptions and guide them. Fagin and Merkle (2003) concluded that robots are no panacea while it is clear that they have positive potential as they discovered that learning with robots neither impacts achievement nor choice of discipline.

While the debate regarding its benefits in education continues, BBC reports that programming is going to replace the current ICT curriculum in the UK deemed irrelevant amidst comments that it teaches the students to only use and not make applications, leaving them bored (Burns in BBC, 2012). Other comments inform about the lack of Computer Science teachers and the discomfort of non-specialist teachers with unconventional teaching resources and the need for teaching training, raising of standards and continuous assessment of the students for successful implementation of the new curriculum. Consequently, it becomes crucial to hear the voice of students and teachers who are the ones faced with the realities in the classrooms if such an implementation takes place. Mayya and Roff (2004) confirms that an important finding in educational research is the positive association of students' perceptions of the learning environment to meaning orientation to learning, which is the capacity to approach topics deeply, interrelate ideas, use evidence and be motivated intrinsically. Other studies state that the success of technology integration in schools is greatly influenced by students' perceptions especially in the amount and ways of technology use (Cope & Ward, 2002). Even the teachers' attitudes to the subject are reflected in their methods and approaches thereby influencing student perceptions (Ahmad & Aziz, 2009). Since student attitudes and perceptions play a crucial role, teachers must clearly plan to reinforce them so as to create a mental climate favourable to learning (Marzano, 1992).

RESEARCH QUESTIONS

This research aims to study the perceptions of the students and teachers regarding the use of robots to learn programming in school. Within this general aim, the following research questions were put forward

1. How do students perceive learning to program with robots?

2. How do teachers perceive using robots as an educational tool?

CONTEXT OF THE STUDY

In order to address these research questions, this study was conducted in a private school in Abu Dhabi which has a good blend of Emirati, Arab and Asian students. The school follows the United Kingdom (UK) curriculum and has a fairly good Information and Communication Technology (ICT) infrastructure. Grade eight students have two ICT periods in a week in computer laboratories and therein they are taught ICT skills and programming. The participants of this study were students and teachers involved in the Robotics classes. The students were generally familiar with using computers at school.

METHODOLOGY

PROCEDURE

Questionnaires were used to explore students' and teachers' perceptions and attitudes using robots in the laboratories to learn programming. The purpose of the study was explained to the students. Some of the questions needed to be explained further as they were English as Second Language (ESL) learners. Interviews were also conducted with the students and the teachers in order to validate the questionnaire responses. Furthermore, an observation was conducted of a Robotics class.

INSTRUMENTS

Self developed questionnaires and interviews were used to collect data. Close-ended as well as open-ended questions were asked. The latter allowed participants to create responses in detail based on personal experiences (Creswell, 2008).

Student questionnaire items covered perceptions of robotics classes to learn programming while teacher's questionnaire contained items to collect demographic information as well as their perceptions of robots as an educational tool. The students and teachers were further interviewed regarding their robotics classes, its advantages and disadvantages. In addition, an observation was conducted of a 40 minute robotics session with the students. More than one data source was used in order to triangulate the study and enhance its accuracy (Creswell, 2008).

PARTICIPANTS

Participants included 26 female students from grade eight and 5 ICT teachers teaching robotic programming. Students were from similar socio-economic status and had fairly good Grade Point Averages. These students were chosen as theirs were the only grade in the school that was taught Robotic programming this particular term and these teachers were the only ones involved.

RESULTS

Student Questionnaire Responses (APPENDIX A)

All students (N=26) responded to the questionnaires.

In response to the question that asked if they enjoyed Robotics classes, 27% responded with 'Don't care or don't like', 54% responded with 'A little' and 4 out of 26 responded with 'Like it a lot' and only one said 'It's my favourite class'.

In response to the question if they understood why they were learning programming, 35% claimed that they ‘did not know’ and only 2 out of 26 assumed it was to enable them to ‘think differently or creatively’.

In response to the questions that asked about their feelings when working with the robots, 61.6 % claimed they were either ‘bored or frustrated’ while the remaining felt they were ’engaged’; and when class is over, 58% stated that they ‘don’t care’ and 27% said they were ‘relieved’.

All students (N=26) recognised the learning potential and only 65% saw any ‘playing’ associated with it.

In response to the questions that asked if the teacher encourages critical thinking, 50% were ’not sure’ while15% affirmed ‘never or don’t care’ ; and if the lessons were structured, 54% responded ‘not sure’ and 11% responded ‘never or don’t care’ ; and if the tasks were clear, only 27% stated’ clear’ and only one said ‘very clear’.

In response to the question if there were any problems in the Robotics classes, 69% responded with’ few resources’ and 23 % mentioned poor classroom management, teacher issues, small lab size and lack of time.

In response to the questions if they discuss about the class later with friends, 50% said ‘never’; and if they reflect or think about the class later, 77% said ‘never or don’t care’.

Teacher Questionnaire Responses (APPENDIX B)

All teachers (N=5) responded to the questionnaires

All teachers (N=5) were ICDL qualified and had teaching experience ranging from 2 to15 years.

All teachers (N=5) required 2-4 hours of preparation time to teach a single 40 minute robotics class.

All teachers (N=5) believed that Robots were powerful learning tools providing motivation, engagement and fun while connecting disciplines such as Maths, Technology and Electronics and encouraging critical thinking and problem solving skills.

All teachers (N=5) recognised the need for training to teach with robots.

In response to the questions that asked the teachers to note the advantages over general ICT classes, they responded with 'more motivation and engagement', 'good group dynamics' and 'self learning'; and to compare their confidence levels in robotics and general ICT classes, all teachers (N=5) stated they were more confident in the general ICT classes.

In response to the question if there were any problems in the Robotics classes, 44% responded with' few resources' and 33 % mentioned poor classroom management, small lab size, lack of time and lack of support.

In response to the questions regarding students attitudes during and when class is over, all teachers (N=5) responded that all students' feelings ranged from 'interested to very interested' in class and from 'slightly upset to very upset' to leave class.

In response to the question that asked what students do when they encounter any problems in constructing or programming, all teachers (N=5) responded with 'Call upon the teacher'.

In response to the question that asked if the teachers felt any change in their roles compared to the traditional one, 4 out of 5 teachers responded that they were performing more than one function as teachers, facilitators and mentors while only one answered 'No change'.

Student Interview Responses (APPENDIX C)

Seven students were interviewed.

The students did not really understand why they were learning how to program robots and they assumed it was perhaps to be trained for the competitions or to have fun in school. Only one student thought it was to enable them to think differently. Most of the students reported hating the class as they felt it was hard work and the ones who claimed they enjoyed it aimed to participate in competitions. Most of the students stated that they just ask the teachers for solutions while one student said that she would try to solve the problems herself and another said that she would discuss with her friends. Other comments included that the robotics classes should be offered as an optional subject or atleast must not be assessed or graded. All the students felt that the classes must be more structured and the students given more time to experiment.

Teacher Interview Responses (APPENDIX C)

Five teachers were interviewed.

The teachers believed that skills such as cooperative, decision-making and problem solving skills were enhanced in the robotics classes. However, only those interested in participating in the competitions were creative. All teachers enjoyed teaching the subject as it did not involve textbooks or notes and believed that robots were valuable to encourage different skills. However, they all agreed that the lessons need to be well structured and the students needed time in class.

Observation Results (APPENDIX D)

One 40 minute robotics class was observed.

The teacher explained the task to be completed only once and did not pose any questions to the class. Seven groups had to work with four robots. Groups that finished programming obtained the robots first while others had to wait for their turn. At any given time, four groups were observed to be off task. Any questions, if raised, were to the teacher and not the other way around. The session ended abruptly with the teacher requesting the students to return the robots. No closure statements or reflections were observed. Students did not seem upset to leave after the session.

DISCUSSION

This study revealed that very few students enjoyed learning to program with robots and very few of them perceived that it taught them to think differently or creatively. Most of them claimed that they were either bored or frustrated. This is consistent with Buckingham's (2007) findings that state the same. All the students perceived its learning potential with a good number seeing no potential at all for play or enjoyment. Most actually considered learning to program as difficult work. Most of the students felt the need for structured lesson planning which was evidently absent when observed. These points refute previous research studies that claim that children were naturally inclined to technology and enjoyed interacting with it (Papert, 1980). Even the teachers recognised the need for structured lessons but claimed that lack of in-class time did not support it. Most of the students even reported that the tasks were not clearly explained to them and that they needed time to experiment. Goldenson (1993) and Palumbo (1990) had correctly claimed that for any kind of higher order thinking skills to be achieved, properly conducted activities and ample time is crucial. Another significant result is that nearly all students did not care or were in fact, relieved when the robotics class was over and a majority reported that they do not discuss with their peers or even reflect upon the classroom activities after class. These results seem to concur with Buckingham (2007) who states that teachers do no concentrate on the critical thinking aspects of programming, thereby rendering the students with only surface level processing of information. This also confirms another study that states the limited ways in which robotics is typically introduced reduces the power and scope of the activities that can offer rich educational opportunities (Rusk et al., 2008).

The students did appreciate the various skills that were enhanced with this learning but could not relate the skills to real life situations. This contradicts Papert (1980) who believed that procedural thinking skills would transfer to other situations. Also, a majority of the students mentioned just asking the teacher for solutions if they came across any problems with programming or even in the construction of the robots. As reviewed in the literature earlier, studies have mentioned the significance of students questioning themselves or peers and not immediately seeking help from the teachers in order to take control of their own learning (Oddie et al., 2010) while other studies (Brand, Collvers & Kasarda , 2008; Barker & Ansorge, 2007) claim that teachers must engage students with questions and discussions to support and reflect learning without just giving away the answers. Students who learn this way seek out new knowledge and thereby more equipped to generalise it and this also results in better long term retention of content. Only a few students claimed that they would attempt to solve the problems themselves or even consult their peers. Even the teachers testified that the students did not collaborate or cooperate. These results refute studies such as Barker and Ansorge (2007) and Beer et al. (1999) which state that such learning promotes teamwork and cooperative learning. An interesting comment from the students was that programming should be offered as an optional subject and must not be graded. This comment was worthy of note as in reply to the BBC news regarding the change in the UK ICT curriculum, a blog comment was noted stating that students must be given the choice to study ICT skills or programming depending upon the area in which they would prefer to develop their skills. Also it is worth repeating literature mentioned earlier that students' perceptions are significant for the successful integration of technology into schools (Marzano, 1992; Cope & Ward, 2002).

Teachers claimed enjoying robotics classes and were positive regarding the value of robots as educational tools and the skills associated with learning to program with them. This will influence the students' perceptions as reported by Ahmad and Aziz (2009). However, they reported that creative skills were perceived only in those keen on competitions and Rusk et al. (2008) had noted that while competitions were motivating for some, they were alienating for others. Teachers also recognised the importance of lesson structure and in-class time which is confirmed by studies that state the structure, organisation, planning and design of activities affects transfer of learning (Goldenson, 1993) and also children need time to connect daily concepts to scientific ones (Carbonaro et al., 2008).

An interesting result was that teachers truly believed that students were interested in the robotics classes and were upset to leave when over, which completely contradicts student reports. Ahmad and Aziz (2009) stress the significance of teachers' awareness of students' perceptions of their teaching to constantly improve the quality of learning environments. Few robots, small lab size and in-class time were enumerated as problems associated with the robotics classes. Teachers added lack of time to prepare lessons and lack of adult support in class to deal with a large group. These results concur with studies that reported poor logistical setups as hindrances (Beals & Bers, 2006) and lack of support to teachers results in minimal guidance during instruction to students which in fact reduces efficiency (Mayer, 2004). Carbonaro et al. (2008) calls for well planned and scaffolded instruction with discussion at critical points to deepen understanding while the same authors along with Rusk et al., (2008) argue that in order to engage students with diverse interests and learning styles, teachers must prepare to accommodate for differentiation by offering multiple pathways to programming. In relation to this, teachers mentioned the need for pedagogical training to teach with robots. The LEGO website (www.legoengineering.com) provides valuable information to educators regarding curriculum, activities, resources and much more but it is clear that the teachers themselves have not been guided appropriately.

One of the limitations in this study is the data sources being self reports. Others include the sample size of the teachers and the sample selection being girls. According to Rusk et al. (2008) boys have more experience building with LEGO materials and may be able to quickly integrate these materials into programming creatively. Also, a recent study has discovered that young Emirati girls tend to see female scientists and engineers as role models, but women studying and working in the field of Science and Technology in the UAE are very low compared to males, thereby these female students are unable to see the relevance of programming in their future (Vidican, 2011). Also, more than one observation may have revealed different results and additional questions in the questionnaire to report the subjects interesting to the participants may have revealed whether they are inclined towards Arts or Science subjects.

CONCLUSION

This study intended to explore the perceptions of students and teachers regarding the use of robots to learn programming in school. It was found that very few students were motivated or even interested in the subject and most found it either boring or frustrating and almost all needed guidance. Teachers were very positive about its educational potential but felt the need to be trained to teach programming with robots. The teachers misconstrued that the students were interested in the subject and actually believed that the students were upset to leave the sessions once over. Both the students and the teachers believed that the lessons need to be structured with adequate time and space to experiment and adequate number of robots. Teachers also perceived the significance of support teachers in class as well as time for preparation of lessons. From this study it is evident that perceptions are significant to modify or improve the quality of educational environments. Future research can look into the design of specific programming activities to promote development of skills such as critical thinking, problem solving, decision making and creativity.

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APPENDICES

APPENDIX A

STUDENT QUESTIONNAIRE

Information about your Robotic programming classes:

29. Do you enjoy your robotics classes?

I don't care about it	I don't like it	I like it a little	I like it a lot	It's my favorite class

30. Why do you think you are learning Programming with robots?

……

……

……

……

31. What skills do you believe you are learning in robotics class? (You may select more than one**[X]** but please provide examples for clarification)

n. Creative ☐ Example:………………………………………………………………………………

o. Critical thinking ☐ Example:………………………………………………………………………………

p. Problem solving ☐ Example:………………………………………………………………………………

q. Designing ☐ Example:………………………………………………………………………………

r. Constructing ☐ Example:………………………………………………………………………………

s. ICT skills ☐ Example:………………………………………………………………………………

t. Others , please specify with example : ……………………………………………………………………

32. When you are working with robots do you feel

Bored	Slightly bored	Engaged/Involved	Slightly frustrated	Frustrated

33. When you are in the robotics class you are

Only Playing	More playing Less Learning	Playing and Learning	Less playing More Learning	Only learning

34. Does your teacher get you to think as opposed to telling you what to do?

Always	Most of the time	Sometimes	Never	I don't care

35. Are the lessons well structured according to you?

Always	Most of the time	Sometimes	Never	I don't care

36. What problems according to you, are there in the robotic classes?

k. Classroom management ☐ Example:...

l. Few resources ☐ Example:...

m. Teacher issues ☐ Example:...

n. Lab too small ☐ Example:...

o. Others ☐ Please specify with example : ....

37. How clearly are tasks presented to you?

I don't have a clue	I understand very few things	Fair enough	Clearly	Very clearly

38. How does teacher behave during the robotics lesson?

Completely nervous	Slightly nervous	Slightly confident	Confident	Very confident

39. How do you feel when you are done with your robotics class?

Relieved	Slightly relieved	No feelings	Slightly upset to leave	Very upset to leave

40. Do you discuss with your friends after the class about what you did in the robotics class?

Always	Most of the time	Sometimes	Never	I don't care

41. Do you think about the activities you did in the robotics class after it is over?

Always	Most of the time	Sometimes	Never	I don't care

APPENDIX B

TEACHER QUESTIONNAIRE

A - Some demographic information

25. How many years of teaching experience?

< 2 years	2-5 years	5-8 years	8-11 years	>11 years

26. Are you ICDL certified? (Please select one box [X])

YES	NO

27. Do you have an internationally recognized teaching qualification for the subject that you are currently teaching? (Please select one box [X])

YES	NO

28. What is your highest ‘completed’ qualification you currently hold? (Please select one box [X])

High school diploma	Bachelors	Masters	EdD	PhD

B – Information regarding Robotic Programming lessons

In this section, I would like you to discuss your perceptions and attitudes before, during and after your Robotic programming lessons. Please be as honest as possible, remember **this is not a test** but an attempt to find out more about teachers and their perceptions about robotic programming as a valuable educational tool. If you have any questions please call the person in charge over.

29. How many hours of preparation are necessary to take a Robotics class?

1-2 hours	2-3 hours	3-4 hours	4-5 hours	>5 hours

30. Do you believe that robots are a valuable educational tool? (Please select one box [X])

YES	NO

Why?

………

………

………

31. What skills according to you, can Robotic programming teach the students? (You can select more than one[X]).

Creative	Critical thinking	Problem solving	Designing	ICT	Others Please specify

32. What kind of positive issues are there in a robotics class compared to other ICT classes you teach? (You can select more than one[X]).

Students motivated	Students engaged	Students manageable	Good group dynamics	Others please specify

33. What kind of problematic issues do you have in your robotics class? (You can select more than one[X]). Please explain further.

Classroom management	Few resources	Students uninterested	Lab too small	Others please specify

……………………… …………………… ……………………… …………………… ……………………

……………………… …………………… ……………………… …………………… ……………………

34. How confident do you feel before every robotics class compared to the other ICT classes you teach?

Completely nervous	Slightly nervous	Slightly confident	Confident	Very confident

35. How confident are you in the general ICT classes that you teach?

Completely nervous	Slightly nervous	Slightly confident	Confident	Very confident

36. What do you think of the students' attitudes to robotics classes before they start?

Not at all interested	Slightly interested	Interested	Very interested	Extremely interested

37. How confident do you feel during the class?

Completely nervous	Slightly nervous	Slightly confident	Confident	Very confident

38. How do you feel after the class is over?

Relieved	Slightly relieved	Satisfied	Quite satisfied	Very satisfied

39. What are the students' attitudes after they are done?

Relieved	Slightly relieved	No feelings	Slightly upset to leave	Very upset to leave

40. Do you have sufficient resources?

More than enough	Sufficient	Can do with more	Very few	Don't have any

41. How do you feel your role as a teacher has changed from when taking a robotics class?

No change in role	More lecturing	Lecturing and facilitating	Facilitating	Lecturing, facilitating & lab assistant	Others Please specify

42. What do your students do when they are faced with difficulties?

Try to solve themselves	Talk to their peers	Call upon you	Give up and stay put	Distract others	Others Please specify

43. How is student behaviour in the robotics lesson?

Chaotic until tasks given	Chaotic throughout	Engaged for a while	Engaged the entire class	Others Please specify

44. Did you receive training as to how to teach programming with robots?

YES	NO

45. Would you like to receive training on how to teach programming with robots?

YES	NO

<u>Appendix – C</u>

INTERVIEW QUESTIONS TO THE STUDENTS

1. Do you know why you are learning to program robots?
2. Do you like Robotics classes? Why/ why not?
3. What do you do when you stuck while constructing or programming the robots?
4. Any comments about the lessons or the subject?

INTERVIEW QUESTIONS TO THE TEACHERS

1. Do you enjoy teaching students to program?
2. Do you think that skills other than constructing and programming are developed in Robotics classes? If yes, name a few please.
3. Do you believe that robots are valuable teaching tools? If yes, how?
4. Do you believe your role changes in Robotics classes? If yes, how?

Appendix – D

Classroom Observation Script

Teacher: …………………………… Period: ……………………
Time: ……………………….. Date: ……………………….
Subject: ……………………. Observer: Ms. Shehla Arif

Time	Observation script	Questions/Comments

	Select as applicable and add comments
Student focussed	
Guided	
Structured	
Integration to other subjects	
Higher cognitive Qs	
Learning targets	
Differentiation	
Effective use of time	
Extension of learning beyond classroom	
Problem-solving with small issues	
Lab preparation before class	
Support system	

LIST OF CHARTS AND TABLES

LIST OF FIGURES