# TEACHERS' PERCEPTIONS OF USING ROBOTICS IN

# PRIMARY/ELEMENTARY SCHOOLS IN NEWFOUNDLAND AND

# LABRADOR

By

© Ahmad Khanlari

A thesis submitted to the

School of Gtaduate Studies

In Partial fulfillment of the requirments for the degree of

**Master of Education**

Memorial University of Newfoundland

**June 2014**

St.John's                          Newfoundland and Labrador

**ABSTRACT**

Robotics, with its multidisciplinary nature, integrates Science, Technology, Engineering, and Mathematics (STEM) disciplines and is considered a gateway to STEM education. This study aims to understand whether primary/elementary teachers perceive robotics as a useful tool for STEM education or not. This study also seeks to better understand primary/elementary teachers' perceptions of the barriers of using robotics and the support that they need. A sample of 11 primary/elementary teachers from Newfoundland and Labrador English Schools District (NLESD) participated in this study. The results of this study revealed that the participants perceive robotics to have the potential to facilitate learning of primary/elementary science and technology-related topics, while they do not perceive robotics to be a useful tool for learning mathematics. The participants also perceived robotics to have positive effects on students' lifelong learning skills. Furthermore, the participants indicated a number of barriers to integrate robotics into their teaching activities and expressed the supports that they need.

**ACKNOWLEGEMENTS**

This thesis would not have come to reality without the help of many people. I would like to thank each and every one of them.

Firstly, I would like to thank my supervisor, Dr. Mary Stordy, for her guidance and encouragement at all stages of the thesis. Secondly, I am grateful to the Newfoundland and Labrador English School District (NLESD), especially the instructors and teachers from that district who willingly participated in my research. Thirdly, I should say thanks to my wife for her never ending encouragement and support. Finally, I thank my Mom, Dad, and my siblings for giving me the continued support and encouragement I needed to complete the thesis.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF APPENDICES

## CHAPTER ONE: INTRODUCTION AND STATEMENT OF RESEARCH PROBLEM

### 1.1 Introduction

Digital technology is well into the 21st century; one does not have to search too far to discover evidence of digital technology in the world. In Canada, it is in our hospitals, our grocery stores, our automobiles, and in our schools. Learning through the use of digital technologies is an essential graduation learning outcome in many provinces in the country, such as Newfoundland and Labrador, Nova Scotia, and Prince Edward Island (Newfoundland and Labrador Department of Education, 2013; Nova Scotia Department of Education, 2003; Prince Edward Island Department of Education, 2007). Technology-rich environments not only have positive effects on students' achievement in all areas (Butler, 2008; Sivin-Kachala, 1998), but also create new ways for developing students' social interaction skills and for encouraging problem solving skills, creativity, and social and cognitive development (Gee, 2008; Kazakoff, Sullivan, & Bers, 2013). Technologies also encourage teamwork and collaboration among students, and create "more democratic, collective, and participatory" spaces (Davis, Sumara, Luce-Kapler, 2008, p. 145).

Some other benefits of including technology education and engineering education in K-12 schools are: (a) to improve student learning in science and mathematics, (b) to increase technological literacy, (c) to engage students in engineering design, and (d) increase knowledge of engineering (Katehi, Pearson, & Feder, 2009). Therefore, it is important to engage students in Science, Technology, Engineering, and Mathematics

(STEM) education during their entire education. It is especially important to engage them in STEM education as early as in elementary school, because "[c]hildren undergo many developmental changes between the ages of 6 and 12, particularly in terms of their cognitive development" (Canadian Child Care Federation, 2010, p. 6). Studies show that STEM education is more effective if it starts in early childhood than if it begins later in childhood, so "the foundations for science and technology [and mathematics] education should be laid as early as the elementary grades" (Marulcu, 2010, p. 2). Early childhood STEM education facilitates students' understanding of subject matter (Marulcu, 2010), reduces barriers for entering jobs related to STEM fields (Madill et al., 2007; Markert, 1996), and diminishes the gender-based stereotypes about STEM careers (Metz, 2007; Steele, 1997). For example, early exposure to engineering education (as a part of STEM education) engages elementary students in intensive content that requires mastery in science and mathematics, so it is a powerful approach for learning mathematics and science concepts and will increase students' technological, scientific, and mathematical literacy (Atman, Kilgore, & McKenna, 2008; Cantrell, Pekcan, Itani, & Velasquez-Bryant, 2006). STEM education, like any other educational intervention, consumes lower costs and has longer-lasting effects at an early age compared to later in childhood (Reynolds, Temple, Ou, Arteaga, & White, 2011; Cunha & Heckman, 2007).

**1.2 Research Problem**

STEM education aims to increase STEM literacy which includes "the knowledge and understanding of scientific and mathematical concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic

productivity for all students" (National Research Centre, 2011, p. 5). Another goal of STEM education is to persuade students to explore degrees and careers in STEM-related fields. Although early childhood STEM education is very important, educators pay little attention to STEM education (e.g. technology education) in the early childhood classroom (Bers, 2008; Marulcu, 2010). In this research study, the focus is on STEM education in primary/elementary schools. I specifically focus on robotics, since it is a "gateway to STEM because it integrates all these different disciplines in an applied way" (Kazakoff et al., 2013, p. 246) and has "the potential to significantly impact the nature of engineering and science education at all levels, from K-12 to graduate school" (Mataric, 2004, p. 1). Furthermore, Rogers and Portsmore (2004) found that one of the best ways for improving students' performance in mathematics and science is conducting simple hands-on activities in elementary schools. Robotics offers students hands-on experience in a wide range of subjects, improves STEM knowledge in students, and provides an alternative teaching method to traditional lecture-style classes (Gura, 2012). A review of literature shows that robotics can help students to learn many subjects, including Mathematics, Physics, Science, Mechanics, Electronics, Computer engineering, Geography, Art, and Biology (Eguchi, 2007; Kolberg & Orlev, 2001; Kazakoff et al., 2013; Marulcu, 2010; Oppliger, 2002; Sklar, Eguchi, & Johnson, 2002; Sklar, Eguchi, & Johnson, 2003). The authors of these studies also found that robotics promotes academic skills, including writing, reading, communication skills, creative thinking, research skills, problem solving, decision-making, and team-working.

Robotics is a useful tool for all students and even children with special and cognitive needs are motivated by robots (Werry, Dautenhahn, Ogden, & Harwin, 2001). Mataric,

Koenig, and Feil-Seifer (2007) stated that no age is too young to be engaged by robots;
even four-year old children can construct and program simple robots (Kazakoff et al.,
2013). Robotics in elementary schools addresses the societal and personal needs of
students by leading them to work together to solve real life problems (Atman et al.,
2008). However, little research has been conducted about robotics and its effectiveness in
STEM education in primary/elementary schools (Faisal, Kapila, & Iskander, 2012). There
is also limited research about teachers' perceptions of using robotics technology in
Primary/Elementary schools. Thus, more exploration is needed to fill this gap in the
existing literature. This project aims to contribute to the research literature by studying
primary/elementary teachers' perceptions of using educational robots.

## 1.3 Purpose Statement and Research Questions

The primary focus of this research is to investigate the effects of robotics on STEM
education in primary/elementary schools by examining teachers' perceptions. The aim of
teaching Science, Technology, Engineering and Mathematics is not only to help students
to further their knowledge in these disciplines, but also to help students to become
lifelong learners. For example, as outlined in the Newfoundland and Labrador
Mathematics curriculum document, "[t]here are critical components that students must
encounter in a mathematics program in order to achieve the goals of mathematics
education and embrace lifelong learning in mathematics" (Newfoundland and Labrador
Department of Education, 2009, p. 5). In fact, mathematics outcomes are categorized into
two different categories: (a) Knowledge and (b) Skills. An education system not only
should provide an opportunity for students to further their mathematical knowledge, but

also should engage students in mathematical processes and create an environment to help students to become lifelong learners, by improving their communication, connection, problem solving, reasoning, and visualization skills.

The education system should create an opportunity for students to represent, listen, and discuss mathematical ideas in different ways and contexts. Communication allows students to clarify, reinforce, and modify their ideas, beliefs, and attitudes about mathematics. It also facilitates learning and helps students to express their understanding. Furthermore, the education system not only should provide an environment for students to connect mathematical ideas to each other, but also should simulate the real world situation and provide an opportunity for students to experience problem solving, social skills, and attitudes that are used in the real world.. Such connections validate students' prior experiences, help students to see mathematics as a "useful, relevant and integrated" discipline, and encourage them to actively engage in the class (Newfoundland and Labrador Department of Education, 2009, p. 6). Therefore, "contextualization and making connection to the experiences of learners" (p. 6) is considered an effective process for developing mathematical understanding and should be emphasized in mathematics curricula.

The Newfoundland and Labrador mathematics curriculum document also emphasizes that "[l]earning through problem solving should be the focus of mathematics at all grade levels" (Newfoundland and Labrador Department of Education, 2009, p. 7) because problem solving helps students to deeply understand concepts, provides an opportunity for students to explore alternative and different solutions, and develops students'

confidence.  Furthermore, education systems should create an environment where students feel confident "in their abilities to reason and justify their mathematical thinking" (p. 7). Reasoning skills help students to analyze a problem, make a conclusion, and justify or defend their conclusion through a logical process; therefore, mathematical reasoning provides an opportunity for students to "think logically and make sense of mathematics" (p. 7). Finally, mathematics teachers and educators should utilize visualization when teaching mathematics. Visualization facilitates student learning by helping them to make connections among mathematical concepts. Visualization, for example, can help students to realize the relationships among and between 3-D objects and 2-D shapes, spatial reasoning, spatial sense, and measurement. Technology, concrete materials, and different visual representations can help to foster visualization.

Moreover, as it has been stated in the Newfoundland and Labrador Science curriculum document, students are expected to learn not only the science discipline, but also how to initiate and plan, perform and record, analyze and interpret, work in a team and communicate (Newfoundland and Labrador Department of Education, 2002). Students should be able to propose questions, investigate problems, present a hypothesis based on the observed patterns, identify different solutions and answers, and select the best answer and solution (initiating and planning skills). They also should explore the given problems, collect relevant information based on their observation, and construct and utilize appropriate devices for their purposes (performing and recording skills). They should learn to classify objects and events based on their attributes, compile data, suggest explanation and descriptions, and suggest improvement for either a designed or

constructed object (analysing and interpreting skills). Finally, students should be able to work as a team and should have the opportunity to communicate their thoughts, results, and procedures with their teammates during science classes (communication and teamwork skills). Teaching strategies and environments that provide such learning opportunities for students construct the basis of lifelong learning. Therefore, we examine teachers' perceptions of the effects of using robotics on the above-mentioned skills, as well as on students' learning of STEM disciplines.

Additional goals and objectives of STEM education in Canada include developing positive attitudes in students about STEM fields, promoting students' interests toward STEM disciplines, and encouraging students to pursue education and careers in STEM-related fields (STEM NS, n.d.; Canadian Association of Science Centre, 2010). Therefore, in this study, I also examine the effects of using robotics, as an educational tool, on students' interests toward STEM disciplines and encouraging them to study and work in STEM-related disciplines.

This study seeks to examine teachers' perceptions of the effects of using robotics as a learning tool in primary/elementary schools. A qualitative case study approach is employed to address the following research questions:

1. To what extent do primary/elementary teachers agree that robotics can help primary/elementary students to learn STEM subjects?
2. To what extent do primary/elementary teachers believe that robotics can improve students' lifelong learning skills (e.g. team working, problem solving)?

3. To what extent do teachers believe that using robotics in the classroom will foster positive attitudes about STEM disciplines in primary/elementary students and can encourage them to pursue their education and career in these fields?

4. What do primary/elementary teachers believe are the barriers of using robotics in primary/elementary schools?

5. What supports do primary/elementary teachers perceive they need?

**1.4 Summary**

The intent of this research is to study and analyze teachers' perceptions of using robotics for STEM education in primary/elementary grades. The overall goal is to provide potential insights that may serve to guide ongoing and future developments in STEM education at the primary/elementary school level. Chapter two provides a review of the literature and the theoretical framework pertinent to this case study. Chapter three provides an overview of the methodology used to collect and analyze the research data. Finally, chapter four presents the gathered data and the analysis of data, discusses the results and the limitations of the study, and provides suggestions for further research.

**CHAPTER TWO: LITRATURE REVIEW AND THEORETICAL FRAMEWORK**

**2.1 Introduction**

Along with robotics technology development, researchers and educators in many countries, including Canada, Japan, South Korea, Taiwan, and the United States, have employed robots to support education (Han, 2012). Robotics might be used as a learning object or as a learning tool (Alimisis & Kynigos, 2009). In the first category (i.e. learning object) robotics on its own is studied as a subject, while in the second category (i.e. learning tool) robotics is used as a tool for teaching and learning other school subjects such as mathematics and science. Several studies (e.g. Attard, 2012; Bauerle & Gallagher, 2003; Druin & Hendler, 2000; Jeschke, Kato, & Knipping, 2008) have shown that hands-on robotics is engaging, creates constructive learning environments that are suitable for a better understanding of STEM disciplines, has positive long-term effects such as attracting students to technological and scientific studies, and leads students to a love of STEM subjects. Robotics also helps students to promote their skills for living in the digital world (Gura, 2012) and has a great impact on developing problem-solving skills, creativity, critical thinking, and collaborative skills (Alimisis & Kynigos, 2009; Barak & Doppelt, 2000; Bers & Portsmore, 2005; Chalmers, 2013; Vernado, 2005).

This chapter represents a review of literature significant to the study relating to: 1) the effects of robotics on learning STEM subjects, 2) the effects of robotics on lifelong learning skills (academic skills related to STEM), and 3) the effects of robotics on students' interests and their attitudes toward STEM-related fields and careers.

**2.2 The Effects of Robotics on Learning STEM Subjects**

Robots are useful aids for teaching mathematics and physics; they can be used in classrooms for explaining difficult concepts because they capture the imagination of many younger people (Cooper, Keating, Harwin, & Dautenhahn, 1999). Robotics also is a useful tool to introduce modern technology to students and provides opportunities for students to actively engage in STEM disciplines, and leads them to explore and think in a constructivist way (Bers & Portsmore, 2005).

In their study, Rogers and Portsmore (2004) examined the effects of using LEGO™ robotics, as an instructional tool, for learning science and mathematics in primary/elementary schools. The results of their study showed that students as young as grade 1 are able to easily learn important science and mathematics concepts using LEGO materials. Robotics projects provide an opportunity for students to solve mathematical problems, including problems related to proportions, positive and negative numbers, square roots, and algebraic equations (Allen, 2013). Other mathematical skills, such as basic algebra, trigonometry, counting, measuring, estimating, and geometry are embedded in designing and programming robots and students can learn these subjects during robotics projects (Gura, 2012; Johnson, 2002; Samuels & Haapasalo, 2012).

Kazakoff et al. (2013) conducted a study examining the effects of robotics on sequencing abilities in a one-week robotics workshop. The participants of this study included 27 pre-kindergarten and kindergarten students who took part in a pre-test and a post-test. The results of this study indicated that robotics not only helps students to learn

science and technology, but also significantly helps them to learn sequencing that is important for many domains, including mathematics, reading, and basic life tasks.

Hussain, Lindh, and Shukur (2006) in their research project, *Programmable Construction Material in the Teaching Situation,* examined the pedagogical effects caused by the application of *LEGO Dacta* materials on the fifth and ninth grade students. They found that LEGO enhances students' understanding of programming (e.g. how to write a program and how to load different programs to the robots). Results showed better performances in mathematics for the trained group in grade 5 as well:

When looking at achievements in mathematics for this group of pupils before and after the training by using the standard two-sample t-test, we find a positive shift in the mean from 0.711 to 0.817 with p-value = 0.000 (which means significant at all significant levels) indicating better performances in mathematics for the trained group. (p. 9)

But the results did not indicate any significant effects on mathematics for the trained group in grade 9:

When looking at achievements in mathematics for this group of pupils before and after the training by using the same standard two-sample t-test as for grade 5, we did not find any significant shifts in the mean with regard to mathematics or problem solving. (p. 9)

Johnson (2002) claimed that the multi-disciplinary nature of robotics provides a unique educational environment for learning electronics, programming, forces, laws of

motion, and physical processes. Furthermore, Carberry and Hynes (2007) in their study realized that underwater robotics activities provide a unique opportunity for 10-13 years old students to learn difficult subjects such as buoyancy, propulsion, balance, and torque. Robotics also has a great impact on learning basic engineering concepts and programming skills, including gearing and gear ratios, torque and acceleration, loops, forks, subroutines, logic, and the use of light, ultrasonic, and infrared sensors (Gura, 2012).

In their study, Carbonaro, Murry, and Chambers (2007), explored the effects of robotics on children's problem solving and reasoning about gears. The participants included 22 grade 2 students (10 girls and 12 boys) from a rural area in Canada. They conducted a pretest and a posttest followed by the *LEGO Dacta* machine intervention in order to examine students' perceptions of the effects of a driver gear on the follower gear. The result of the posttest showed that robotics intervention improves students' perceptions of relative speed (faster, slower, or same speed) of the follower gear. The results also indicated that using robots increases correct answers on the large-large, medium-small, and medium-small-medium combination of gears and helps students to revise their ideas about the relation between the number of gears and the relative speed of the follower gears.

In his study, Grubbs (2013) examined the effects of robotics on learning science concepts in middle schools. He expressed that robotics not only improves students' STEM skills, such as problem solving skills, but also encourages their interests toward the content they are provided. The results of this study indicated that robotics improves

"students' ability to understand electron flow, OHM's law, series and parallel circuits, as well as basic arithmetic and understanding the big idea for equations" (p. 16).

Bers, Ponte, Juelich, Viera, and Schenker (2002) claimed that robotics allows students to design and build interactive artifacts during playful experiences; therefore, it is an innovative method for teaching technology and engineering concepts, such as gears, motors, and sensors. Petre and Price (2004) conducted a case study in primary and secondary schools and examined the effects of robotics on understanding principles and concepts of programming and engineering. The authors indicated that students' learning during robotics activities is concrete and associated with their creation, observation, and interaction. The results of this study revealed that robotics helps students to learn topics that previously were difficult for them, such as programming, gearing, and mathematical representations.

Barker and Ansorge (2007) conducted a quasi-experimental study in a rural elementary school, and examined the effects of an after school LEGO robotics program on the understanding of science, engineering, and technology in 9-11 years old students. The results showed a significant increase in mean scores on the post-test of students in the robotics intervention, but no significant change in scores from the pre-test to the post-test in the randomly selected control group.

Chambers, Carbonaro, and Rex (2007) conducted a pilot case study in order to examine the effects of robotics intervention on students' problem solving skills and knowledge development in a middle school class, including grade 7, 8, and 9 students.

The authors found that constructing and manipulating robots help students to understand a variety of scientific concepts, including force and motion, simple machines, mechanical advantage, speed ratios, and force ratios. The result of this study indicated that flowcharting helps students to organize their ideas and programming robots improves their level of critical thinking and reflective thinking. The authors concluded that robotics projects not only help students to construct knowledge, but also improve their problem solving.

Nugent, Barker, Grandgenett, and Adamchuk (2010) conducted a quasi-experimental study to examine the impacts of robotics and geospatial technologies interventions on middle-school students' learning of Science, Technology, Engineering, and Mathematics. The results of a content test covering topics in computer programming, mathematics, geospatial technologies, and engineering showed that students who attended in 40-hour intensive robotics/GPS/GIS summer camp learn STEM subjects better, compare to students in the control group who did not receive such an intervention.

Chambers, Carbonaro, and Murray (2008) conducted a study to explore the effects of a LEGO robotics course on elementary students' understanding of gear function and mechanical advantage. They concluded that robotics sessions improve students' understanding of gear function in relation to direction of turning, relative speed, and number of revolutions. Also, Martin (1996) applied the *Programmable Brick*, a new educational technology that was an extension of LEGO, to introduce technology to the classroom. The Programmable Brick combined the functionality of the desktop computer and the interface to the LEGO motors and sensors into a single brick. He found that the

Bricks expand design and learning possibilities and children effectively learn technology when they are engaged in design, construction, and debugging activities.

Williams, Ma, Prejean, and Ford (2007) conducted a mixed method study and explored the impact of a robotics summer camp on middle-school students' physics content knowledge. Participants of this study included 21 middle-school students who enrolled in the robotics summer camp and also their 10 facilitators. The results of this study revealed that the robotics camp enhances students' physics content knowledge:

> Statistical analysis indicates a significant difference on the physics content knowledge measure from pretest to posttest $t(20) = -3.275$, $p = .004$ (MEAN pre = 8.40; MEAN post = 9.75). That is, robotics summer camp had a statistically significant impact on student gains in physics content knowledge. (p. 5)

Faisal et al. (2012) in their study examined the effects of using LEGO robotics as an educational tool on engaging fourth-grade students in mathematics and enhancing their visual understanding of concepts. The analysis of the pre- assessment and post-assessment tests revealed that robotics increases students' performance: "the average performance of the class increased from 36% to 92% after the activity" (p. 10). The authors also reported that robotics helps 87% of students to learn and improves their understanding of abstract concepts such as unit conversion.

According to the existing studies, robotics is an engaging activity that helps students to understand STEM disciplines in three different ways: (1) by providing visual and hands-on activities (e.g. Faisal et al., 2012), (2) by immersing students in problem solving

through Problem-Based Learning (e.g. Allen, 2013), and (3) by creating authentic education that connects the lessons with students' real-lives and their prior knowledge (e.g. Samuels & Haapasalo, 2012; Whitehead, 2010).

### 2.2.1 Providing visual and hands-on activities

Educational robots, as a new type of learning manipulative, improve students' understanding of mathematical concepts, such as numbers, sizes, and shapes (Brosterman, 1997). Weinberg and Yu (2003) stated that robotics provides a unique learning experience by providing physical embodiment of computation; students receive strong visual feedback from physically experiencing their work. They explore, make hypotheses about how things work, and conduct experiments to validate their beliefs and assumptions.

Faisal et al. (2012) interpreted the results of their study and stated that robotics helps students to understand abstract topics "with visual and conceptual ease" (p. 13) and facilitates remembering of the learned subjects. Furthermore, the authors concurred with Adolphson (2005) and Brosterman (1997) that hands-on nature of robotics creates an active learning environment and increases conceptual understanding of subject matter.

Carbonaro, Rex, and Chambers (2004a) employed LEGO robotics to teach computer and science to students in grades 7, 8, and 9; they conducted an action research project to examine the effects of robotics on learning computer and science subjects. The authors found that robotics provides a challenging learning environment in which "the abstract levels of concepts (programs) are directly mapped to the concrete physical level (robots)

and that students themselves can observe the results of their designs at both levels" (p. 4549). The authors concluded that robotics projects make science fun and improve students' scientific conceptual understanding and knowledge, because they have the opportunity "to manipulate and observe the gears, motion and forces" (p. 4549).

Klassner and Anderson (2002) stated that their own (and others') experiences show that hands-on robotics projects significantly motivate students to learn computing principles. The authors stated that robotics visualizes the design of algorithms and also provides an opportunity for students to experience hands-on activities; therefore, robotics can facilitate learning of topics such as Programming Fundamentals, Algorithms and Complexity, and Programming Languages.

### 2.2.2  Immersing students in problem solving through Problem-Based Learning

The most important and difficult subjects can easily be taught through problem solving (De Walle, Folk, Karp, & Bay-Williams, 2011); therefore, problem solving is the most important thing that teachers should teach their students (Houghton, 2004). As problem solving is considered an effective and powerful teaching and learning method (De Walle et al., 2011), one of the goals of STEM education in Canada is changing traditional teacher-centered education and "encouraging a curriculum that is driven by problem-solving, discovery, exploratory learning, and require students to actively engage a situation in order to find its solution" (STEM NS, n.d., para. 1). Solving problems through the Problem-Based Learning approach allows students to have positive attitudes toward the subjects and increases their higher order thinking skills (Harris, Marcus, McLaren, & Fey, 2001). Problem-based learning also helps students to deeply learn the

subject matter and not to forget what they have learned (De Walle et al., 2011). Since immersing students in the problem leads them to deeply think and inquire about the cause and effect of phenomena and to search for the solutions, "the curriculum and instruction should begin with problems, dilemmas, and questions for students" (Hiebert et al., 1996, p. 12). Learning through problem solving helps students to learn "through real life context, problems, situations, and models" (De Walle et al., 2011, p. 30).

Educational robots provide teachers with an opportunity to integrate "engaging problem-solving tasks" (Highfield, 2010, p. 22) into the mathematics curricula. Samuels and Haapasalo (2012) in their study concluded that using educational robots is an effective way for teaching and learning mathematics through problem based learning and has "the potential for being combined in a creative collaborative problem-based approach" (p. 298). Adams, Kaczmarczyk, Picton, and Demian (2010) used Lego RCX and Lego Mindstorm NXT robots to motivate students to develop creative problem solving skills during a problem-based learning approach. The results of this study indicated that robotics supports the problem based learning approach and is an effective and exciting tool for generating and solving problems. They also concluded that most of the participants agreed that robotics improves their creative problem solving skills. Therefore, using robotics is an effective approach for problem solving through problem based learning that improves students' understanding of subject matter (Striegel & Rover, 2002; Vandebona & Attard, 2002).

**2.2.3 Authentic education: connecting the lessons with students' real-lives and their prior knowledge**

While authentic learning environments focus on solving real-world problems by employing interdisciplinary approaches (Lombardi, 2007), and "students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge" (National Council of Teachers of Mathematics [NCTM], 2000, p. 20), the subject matter when using a traditional method of teaching is "divorced from real experience" (Samuels & Haapasalo, 2012, p. 290). Making connections to real-world leads students to believe that math is relevant, integrated and useful, helps them to develop their mathematical understanding, and encourages their willingness to be actively engaged (Alberta Education, 2007). Authentic education not only connects the curriculum with students' prior knowledge, but also provides an opportunity for students to "work directly with high-quality, real-time data about human gait in much the same way movement scientists do" (Heck & Holleman, 2003, p. 381) and helps students to experience problem solving. Grubbs (2013) claimed that such authentic lessons, which are connected to the real-life, help students in the process of learning, because they "see the lesson as meaningful and relevant" (p. 13). One of the methods that helps students to make connections between the learned subjects and their lives *is project-based learning* (Boaler, 2002). Project-based learning includes five different processes: engagement, exploration, investigation, creation, and sharing (Carbonaro, Rex, Chamber, 2004b). The project context of project-based learning allows students to learn relevant subjects in a personalized and meaningful context (Penner, 2001), links students to meaningful life

experiences, engages them in complex activities, leads them to construct readily sharable artifacts, and encourages them to share their ideas (Carbonaro et al., 2004b). Indeed, encouraging students to construct their own knowledge of real-life through projects facilitates their learning, improves their achievement, and promotes scientific and mathematic problem solving abilities (Satchwell & Loepp, 2002). Projects also encourage students' interests toward science, technology, engineering, and math (Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naamand, 2005).

Robotics is applicable for project-based learning and provides students with the opportunity to learn with the technology, rather than learning from technology (Hung, 2002). Robotics projects contextualize the typically decontextualized abstractions that are taught in the classroom (Adolphson, 2005) and provide an opportunity for students to "connect and apply science concepts" such as current, voltage, and resistance and apply mathematics concepts such as scaling and graphing, prediction, and calculating wheel rotation (Grubbs, 2013, p. 12). This connection illustrates "relevant applications of theoretical principles in everyday contexts" and therefore motivates students to study mathematics and science in an excellent platform (Bers & Portsmore, 2005, p. 60). Such a connection provides students with an authentic learning experience that reduces the ambiguity of the processes and therefore facilitates the learning.

Furthermore, design-based activities in robotics projects lead students in different ages to apply learned mathematics and physics and also to utilize concepts, skills and strategies to solve real-world and personally meaningful problems that are embedded in robotics projects (Bers, 2007; Dopplet, Mehalik, Schunn, Silk, & Krysinski, 2008; Faisal

et al., 2012; Kilgore, Atman, Yasuhara, Barker, & Morozov, 2007; Papert, 1980; Resnick,

Berg, & Eisenberg, 2000; Samuels & Haapasalo, 2012 Whitehead, 2010). When working

on robotics projects, students encounter "applied, real world challenge[s] such as an

engineering problem to solve or a novel science investigation to perform" (Church, Ford,

Perova, & Rogers, 2010, p.47). The authors claimed that robotics projects help students

to solve real world problems such as "Testing Speed vs. Acceleration of Drag Cars,"

"Simple Harmonic Motion," and "Microphone Sound Reduction" (p.48). Resnick,

Martin, Sargent and Silverman (1996) asked a group of students to make a live

environment using their programmable bricks. Some students made a light switch which

turned on when people entered and turned off when they left. Other students created

autonomous robotic animals, based on a study about how real animals live and behave.

The authors realized that robotics creates an authentic learning environment based on

students' observations, ideas and prior knowledge and has the potential to provide an

opportunity for students to act as designers and inventors. Therefore, robotics with its

project-based and designed-based nature facilitates STEM learning and also encourages

students' interests toward STEM subjects, by creating an authentic learning environment.

## 2.3 Effects of Robotics on Lifelong Learning Skills (Academic Skills Related to STEM)

In this project, I examine the effects of LEGO robotics on STEM education in

primary/elementary schools. The aim of STEM education is not only to further students'

knowledge of Science, Technology, Engineering, and Mathematics disciplines and

facilitate their learning, but also to provide an opportunity for students to embrace

lifelong learning in STEM education (Newfoundland and Labrador Department of Education, 2009). The main goals of mathematics education include promoting students' communication skills "in order to learn and express their understanding", helping students to "develop and apply new mathematical knowledge through problem solving", developing "mathematical reasoning", and developing "visualization skills to assist in processing information, making connections and solving problems" (Newfoundland and Labrador Department of Education, 2009, p. 5). Students are also expected to "connect mathematical ideas to other concepts in mathematics, to everyday experiences and to other disciplines" (p. 5). Furthermore, as it has been stated in the Newfoundland and Labrador Science curriculum documents, students are expected to learn not only science subjects, but also initiating and planning, performing and recording, analysing and interpreting, communication and teamwork (Newfoundland and Labrador Department of education, 2002).

Eguchi (2007) stated that robotics curriculum helps students to utilize mathematical analysis, scientific inquiry, and engineering design for solving problems and developing solutions. She also stated that robotics curriculum helps students to "become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry" (p. 2456). Hands-on robotics can also improve three-dimensional thinking and visualization, and can improve students' technological literacy (National Academy of Engineering & National Research Council, 2002; Miaoulis, 2001; Sadler, Coyle, & Schwartz, 2000).

Physical robots are "transitional objects" that provide an intermediate stage between formal and concrete reasoning (Eisenberg, 2003) and help primary/elementary students to promote their reasoning and problem solving skills (Clements, Battista, & Sarama, 2001). Robotics projects also challenge students to think about different possible solutions, develop their solutions, and articulate their understanding and reasoning (Chalmers, Chandra, Hudson, & Hudson; 2012).

Gura (2012) stated that robotics helps students to improve skills which are difficult to learn through traditional classes but are "key scientific and engineering practices" (p. 16). The author also stated that "[A]sking questions and defining problems, planning and carrying out investigations, and engaging in argument from evidence" (p. 16) are some of the skills that are encouraged in robotics classes. He also reported that robotics not only helps students to learn and understand mathematics subjects such as distance, time, power, and force, but also helps them to promote problem solving and teamwork skills, thinking skills, developing and reflecting on their learning, and working as an engineer. Faisal et al. (2012) in their study claimed that robotics encourages students to become active researchers, develops their problem solving, communication and collaboration skills, helps them to make connections between science, technology and mathematics, and learn visual abstract scene and mathematics.

Cameron and Barrell (2002) utilized robotics in a grade 2 class, in order to answer students' questions about Mars and its characteristics such as gases, temperature, soil, and air. Students had to think about and discover the best structure for a discovery robot and program their robots to gather scientific evidence. The authors claimed that this project

provided an opportunity for grade 2 students to experience scientific processes and to do the same tasks that researchers at NASA and the Jet Propulsion Laboratory (JPL) do; for each project, group members decided about the best approach for achieving the goals and reported their plan to the teacher. Each group formed smaller sub-groups to do specific tasks, including research about Mars and designing and building an appropriate robot to do the assigned task. Based on the authors' observations, robotics not only provided an opportunity for students to experience the scientific process, but also improved students' communication and collaboration; at the end of each session, all the students shared their experiences (learnings and failures), ideas, solutions for problems, and their future strategies. They also experienced authentic and real-life situations and learned that solving real problems is not as smooth as they usually think and sometimes requires long periods of effort.

Highfield (2010) and Bers and Portsmore (2005) stated that problem solving is one of the processes that students explore in robotics projects. The authors stated that problem solving includes the following steps: predicting, estimating, and examining (estimation step); observing the program, reflecting on attempts, and modifying the program (reflection step); trying the program and identifying the probable errors (trial and error step), applying prior knowledge and skills (recall of prior knowledge), predicting and offering different solutions to tasks (investigating multiple solutions), evaluating the efficiency of the program (evaluating solutions).

When working on robotics projects, students exercise the process of problem solving, including defining problems, analyzing situations, gathering required information,

generating creative ideas, developing their ideas into appreciable solutions, and evaluating and improving the solutions (Whitehead, 2010). During robotics activities, students collaborate within a group, do research and gather information by brainstorming, design robots using basic electrical components (e.g. resistors, wires, and sensors) and mathematical calculations and predications through a problem-solving process that includes planning, designing, evaluating and adjusting, and proposing a robotics program (Grubbs, 2013).

Chambers, Carbonaro, and Rex (2007) claimed that robotics projects not only facilitate learning of scientific concepts, but also create a "peer-supported learning environment" (p.66) for students to share their ideas and thoughts to each other; therefore, robotics improves students' communication skills. Robotics projects engage students in "negotiation" and "social interaction" to communicate, and help students to learn how to function in the social world (Atman et al., 2008; Bers, 2007; Grubbs, 2013; Resnick, 2003).

Other studies (Adams & Turner, 2008; Barak & Zodak, 2009; Benitti, 2012; Castledine & Chalmers, 2011; Cejka, Rogers, & Portsmore, 2006;  Gura, 2012; Highfield, 2010; Hussain et al., 2006; Mosley & Kline, 2006) stated that robotics elegantly and authentically integrates STEM in hands-on experiences and can increase students' engagement, creativity, teamwork, communication, authentic research and information gathering, information evaluating, decision making, problem-solving, and understanding of subject areas such as engineering and computing, and utilizing basic skills in real-world applications.

**2.4 Developing Students' Interests and Positive Attitudes Toward STEM Fields and Careers**

Robotics is an engaging tool that creates an exciting learning environment, improves students' attitudes and interests toward STEM subjects (Fagin & Merkle, 2003; Faisal et al., 2012; Mauch, 2001; Robinson, 2005; Whitehead, 2010), and encourages students to participate in STEM activities and pursue STEM-related careers (Ludi, 2012; Nugent et al., 2010; Nugent, Barker, White, & Grandgenett, 2011; Welch & Huffman, 2011).

Grubbs (2013) stated that robotics creates an exciting and authentic environment that provides students with the opportunity to apply their knowledge that they thought is unusable; therefore, robotics encourages students to pursue a STEM field in the future and has the potential to increase the number of students entering STEM fields. Allen (2013) in a study expressed that robotics has the potential to present a strong example of STEM education in middle schools, is a powerful tool for changing students' perceptions of STEM fields, and leads students to "fall in love with these subjects and all that science, technology, engineering, and mathematics make possible in our world" (p. 345). Allen also stated that robotics helps students to "see themselves as future scientists, tech specialists, engineers, and mathematicians" (p. 345) and can prepare students in all grade levels to succeed in the future that is strongly STEM-based. Allen claimed that many students who are now studying or working in the STEM fields (or even have plans to do so), "never could have envisioned without their robotics experience" (p. 345).

Robotics competitions, like robotics curriculum, provide an engaging context for learning STEM subjects that promotes students' interests toward STEM-related fields

(Johnson & Londt, 2010; Welch, 2010). Students who participated in FIRST (For Inspiration and Recognition of Science and Technology) robotics competitions were "[m]ore than three times as likely to have majored specifically in engineering", "more than twice as likely to expect to pursue a science or technology career", and "nearly four times as likely to expect to pursue a career specifically in engineering" (Melchior, Cohen, Cutter, & Leavitt, 2005, p. 6). Based on the FIRST's report (2006), 69% of the students who participated in FIRST robotics competitions during 2002 to 2005 were more interested in working in science and technology related careers.

## 2.5 Theoretical Framework

The theoretical framework for this study is based on the principles of constructivism, constructionism, learning by design, and design-based learning.

### 2.5.1 Constructivism Theory

The existing literature concurs with the constructivism theory (Piaget, 1972, 1973, 1977). Piaget emphasized that learning takes place as a result of mental construction by the learner. Constructivism considers an active role for learners and emphasizes that the learner gains an understanding of the features and constructs his/her own conceptualizations, knowledge, and solutions to problems by exploring from the environment and interacting with objects and events through personal experiences (Goldman, Eguchi, & Sklar, 2004; Siegler, 1986). In constructivism approach, "a learner is actively constructing new understandings, rather than passively receiving and absorbing 'facts'" (Jacobson & Wilensky, 2006, p. 12). According to this approach, when teachers directly give information to students, immediate understanding and the ability of

using the gained information do not occur (Whitehead, 2010). Constructivism states that teaching should be an indirect process and conceptual changes in children take place as a result of immersing in real-world situations and interacting with people and things (Ackermann, 2001).

Jacobson and Wilensky (2006) found that this approach to learning increases students' understanding of complex systems and promotes interest, engagement, and motivation for students when assigned authentic problems in cooperative learning environments. Using robotics changes teachers' and students' roles; teachers "play a new role different from that of a traditional transmitter of knowledge to a passive audience" (Alimisis, 2007, p. 207), while students play a more active role. Jadud (2000) stated that robotics supports constructivism by providing an opportunity for students to generalize from their experiences and to make connections between experiences and curriculum.

### 2.5.2  Constructionism Theory

Constructionism (Papert, 1980, 1992) draws on constructivism and stresses a hands-on aspect and self-directed learning. Constructivism "tends to overlook the role of context, uses, and media, as well as the importance of individual preferences or styles, in human learning and development" (Ackermann, 2001, p. 4). On the other hand, compare to constructivism, constructionism is more situated and more pragmatic; constructionism considers important roles for contexts, individual minds and their favorite representation, artifacts and learning through hands-on experience (Ackermann, 2001). Papert emphasizes that designing and building a tangible and personally meaningful object,

finding problems, and solving them is the most efficient way to learn powerful ideas. Papert describes constructionism as below:

> Constructionism —the N word as opposed to the V word— shares contructivism's view of learning as "building knowledge structures" through progressive internalization of actions… It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe. (Papert, 1991, p.1, as cited in Ackermann, 2001).

Overall, constructivism and constructionism state that students construct, constantly reconstruct, and progressively develop their knowledge and current view of the world, through personal experience. However, constructionism states that ""diving into" situations rather than looking at them from a distance, that connectedness rather than separation, are powerful means of gaining understanding" (Ackermann, 2001, p. 8). The goal of constructionism is to give "children good things to do so that they can learn by doing much better than they could before" (Papert, 1980, para.4). Papert argued that using the Lego NXT in the classroom allows for a constructionist approach to benefit instruction and student learning. Furthermore, Bers et al. (2002), and Bers and Urrea (2000), Rogers and Portsmore (2004), and Whitehead (2010) found that robotics supports Constructionism theory by developing meaningful learning and understanding through hands-on and cooperative activities. For example, programming robots, as a general model-building, supports the constructionism theory (Papert, 1992). Lego Mindstorm, with its building materials (e.g. blocks, gears, pulleys, and axels), sensors (light, touch,

and sound), and programming software supports a constructionism approach and provides a unique opportunity for students to experience hands-on projects and design and to construct their own robots (Resnick et al., 1996).

### 2.5.3 Learning by Design Theory

Learning by Design (Kolodner, Crismond, Gray, Holbrook, & Puntambekar, 1998) activities provide an opportunity for students to learn while appropriately reflect on their experiences and collaboratively engage in design activities. Students learn what they need to learn while trying to design something; they learn science concepts better through hands-on experience and real-world applications. Based on the different studies (e.g. Kolodner, Gary & Fasse, 2002; Nagel & Kolodner, 1999; Puntambekar & Kolodner, 1998) Learning by Design enhances problem-solving, decision making, and collaboration skills.

### 2.5.4 Design Based Learning Theory

Design Based Learning (DBL) includes two distinct cycles: (1) design/redesign cycle, and (2) investigation and exploration cycle (Kolodner et al., 2003). The first cycle (i.e. design/redesign cycle) includes the following procedure: learners play with tools to understand the challenges, they engage in a problem based learning in order to define what should be investigated, finally the learners plan a design, and then construct, test, and analyze it. In the second cycle, learners clarify the question and make a hypothesis; they design, conduct and analyze an investigation and finally present and share it. Using robotics for STEM activities within a Design-Based Learning project benefits students. It

strengthens the connection between content and real world applications for the students (Dopplet et al., 2008).

The review of literature demonstrates that robotics supports constructivism, constructionism, Learning by Design, and Design-Based Learning; robotics provides meaningful hands-on learning experience, provides authentic learning environments and helps students to make connections between experiences and curriculum, improves students' lifelong learning skills, and actively engages students with STEM education.

## 2.6 Summary

The literature presented in this chapter highlighted a few important aspects of using robotics for educational purposes that informed the development of this study. The review of the literature revealed that robotics is an effective way for learning STEM-related subjects, because it provides visual and hands-on activities, connects the subject matter with students' real lives, and provides a unique problem-based learning environment. According to the existing studies, robotics also helps students to become life-long learners and encourages students to continue their education and career in STEM-related fields. This literature has provided a foundational history and presented concepts and research that were used in the development and design of this study and the analysis of data.

Chapter Three provides an overview of the methodology used to collect and analyze the research data and findings.

## CHAPTER THREE: METHODOLOGY

The first and second sections of this chapter review the methodology of this thesis. The next sections of this chapter describe the procedure of the research, including participant recruitment, instrument development, surveys, and analysis of data.

### 3.1 Qualitative study

The purpose of this study is to examine the perceptions of Newfoundland and Labrador teachers toward using robotics in primary/elementary schools. This study is qualitative in nature, since its goal is to describe what teachers think about using robotics in primary/elementary schools. As Merriam (1988) stated, "[q]ualitative research is a journey of discovery rather than confirmation" (p. 18) in which researchers explore and develop an understanding of others' experiences and thoughts, and encompass many diverse methodologies. In qualitative research, researchers focus on the ways in which people understand and make sense of a topic, and the ways in which the topic affects people (Mac Naughton & Hughes, 2009). In fact, qualitative methodology is considered an effective and powerful approach to enhance understanding of teaching and learning, leads researchers to an in-depth understanding of people's experiences in a specific environment (Patton, 2002), and allows educators to "engage in research that probes for deeper understanding rather than examining surface features" (Johnson, 1995, p. 4). As Henderson (1991) stated, qualitative research is a good way of gaining insight into "POBA"; Perceptions, Opinions, Beliefs, and Attitudes.

## 3.2 Case Study

In this study, qualitative research technique derived from case study methodology has been employed to gather and evaluate data. Case study research is well-suited to an in-depth exploration of a case, a bounded system, or complex issues; including an activity, an event, a process, or individuals that are not well understood (Creswell, 2007). "*Bounded* means that the case is separated out for research in terms of time, place, or some physical boundaries" (Creswell, 2012, p.485). Creswell continued his expression: "[t]he "case" may be a single individual, several individuals separately or in a group, a program, events, or activities (e.g., a teacher, several teachers, or the implementation of a new math program)" (p. 485). Case study is valuable for creating deep and comprehensive understanding of particular people, problems or situations (Patton, 2002) and provides rich information about the topic (Fiese & Bickman, 1998). Merriam (1998) claimed that "[a] case study design is employed to gain an in-depth understanding of the situation and meaning for those involved. The interest is in process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation" (p. 19). This study is particularly suitable for a case study design because it includes a bounded system, which is the implementation of robotics programs in primary/elementary schools. A case study design is chosen for this research because it involves "detailed, in-depth data collection involving multiple sources of information rich in context" (Creswell, 1998, p. 61).

**3.3 Research context**

Based on the review of literature, technology in general and robotics in particular have provided unique opportunities for educators to teach STEM subjects in a new effective way that facilitates students' learning and promotes their interests toward STEM-related activities. This study examines some Newfoundland and Labrador teachers' perceptions of using robotics for STEM education in primary/elementary schools. This study also seeks to realize teachers' perceptions of the barriers of using robotics in primary/elementary schools and the supports they need.

**3.4 Participants and data collection**

The potential participants of this study included any teachers in primary/elementary schools in Newfoundland and Labrador English School District. A list of potential participants was provided and, with permission from the school district, they were contacted through email, requesting their participation in this study. The invitation email described the study and included the informed consent form as well as two links which directed the participants to the website of the study and an online survey (See Appendix C). Although the participants had two options to either participate in a face-to-face interview or fill out an online survey, all 11 participants participated in the study by completing the online survey.

**3.5 Instruments**

As the participants are primary/elementary teachers who may have little or no experience in using robots as an educational tool, a website had been created in order to

provide participants with useful information about robotics. This website included information about using robotics for educational purposes and provided some video clips and an article about educational robots. The participants were asked to review the website and read and watch the materials inside the website before the interview sessions or completing the online surveys if they do not have any experience with (or any information about) using robotics for educational purposes.

A brief agenda for the semi-standardized, open-ended interviews was created. This agenda included important questions that should be asked and also other potential questions. An online survey was created and its link was sent to participants. The online survey was divided into four sections, including background and teaching style, experience with technologies, integration of robotics, and teachers' overall perceptions of robotics. Interestingly enough, all the participants preferred to complete the online survey rather than participate in face-to-face interviews, because some of them are living far from St.John's and the others were very busy with their teaching.

The purpose of the first section was to generate background information from teachers, including their total years of teaching experience, the grade that they are teaching, their teaching methodology, and their access to technology. Section two included specific questions related to their experience with educational technology. Section three was created using questions about participants' experiences and perceptions of integrating robotics in primary/elementary schools, as well as scales that focused on the potential obstacles and potential benefits of using robotics in primary/elementary grades. The 5-point Likert Scale used for the potential benefits consisted of: Strongly

Disagree, Disagree, Neutral, Agree, and Strongly Agree. Finally, section four included short statements about teachers' perceptions of educational robotics.

To ensure anonymity, survey responses were numbered (e.g., Teacher 1). The results from this survey were then analyzed using Google survey analyzer.

## 3.6 Researcher

I have several years of experience in designing robotics curriculum and teaching robotics to students. I have a master's degree in electrical and communication engineering that gives me a good understanding of technology and using it for educational purposes. I worked hard to set aside any prejudgments to perceive teachers' thoughts and concerns accurately.

## 3.7 Data Analysis

In case studies, examining more than one case provides an opportunity for researchers to observe outcomes across all cases and leads researchers to a comprehensive understanding and theorizing (Brantlinger, Jimenez, Klingner, Pugach, & Richardson, 2005). When multiple cases are examined, each case should be analyzed separately and then a cross-case analysis should be conducted to find the similarities and differences of all cases (Creswell, 2012). The online survey company, Google, provided the data in forms of tables and graphs. In this study, each survey is transcribed completely, read precisely, and coded completely based on the similarities.

**3.8 Summary**

   A qualitative case study method was chosen for this study. This study focused on teachers' perceptions of using robotics in primary/elementary grades, especially for STEM education. The participants in this study included 11 primary/elementary teachers. Data gathered in this study and the analysis of the data are presented in chapter four. Chapter four also discusses the results and the limitations of the study, and provides suggestions for further research.

**CHAPTER FOUR: PRESENTATION AND ANALYSIS OF THE DATA**

The objective of this research was to reveal the current perceptions of primary/elementary teachers regarding the use of robotics for STEM education in Newfoundland and Labrador schools. The data collected through the completed surveys revealed some crucial information about teachers' perceptions of integrating educational robots into their teaching activities. In this chapter, the data gathered from the online surveys is summarized into tables and graphs. Moreover, the analysis of the data along with suggestions for further research is presented.

**4.1 Survey Section 1: Teachers' Background**

The participant sample was comprised of 11 primary/elementary teachers. Eight participants were female and the rest preferred not to declare their genders. One of the participants did not finish the survey, after answering only the first 15 questions, but he/she submitted the survey. The majority of the participants (55%) claimed that they prefer more student-centered classes than teacher-directed classes; however, two participants (18%) stated that they prefer largely student-centered classes, two participants (18%) preferred even balance between teacher-directed and student-centered activities, and one participant (9%) preferred largely teacher-directed activities (e.g., teacher-led discussion, lecture). The aim of the next two questions in this section was to realize teachers' perceptions of student and teacher access to educational technology. The results show that all participants perceived access to educational technology resources to be above 60% (Table 1).

**Table 1. Student and teacher access rate to educational technology.**

| Participant | Student access to educational technology (%) | Teacher access to educational technology (%) |
|---|---|---|
| Teacher 1 | 75 | 60 |
| Teacher 2 | 65 | 65 |
| Teacher 3 | 90 | 90 |
| Teacher 4 | 70 | 70 |
| Teacher 5 | 85 | 85 |
| Teacher 6 | 70 | 70 |
| Teacher 7 | 70 | 70 |
| Teacher 8 | 75 | 75 |
| Teacher 9 | 60 | 60 |
| Teacher 10 | 80 | 90 |
| Teacher 11 | No response | No response |

## 4.2 Survey Section 2: Teachers' Experience with Technologies

The first question in Section 2 was about integration of various technologies in the participants' general teaching activities. Among all participants, eight teachers (73%) stated that they frequently use technologies in their classes, two participants (18%) claimed that they almost always use technology in their teaching activities and one participant (9%) stated he/she does not use technology while teaching (Figure 1).

**7. Please indicate how often you integrate various technologies (e.g. computer technologies, smart boards, clickers, etc.) in your teaching activities.**
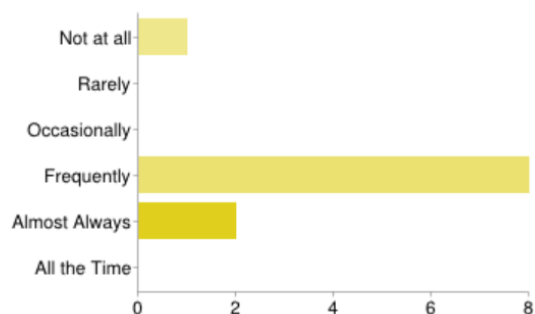


**Figure 1. Participnts' responses regarding the integration of various technologies into their teaching activities.**

Following this question, the participants were asked to indicate what kind of technologies they use in an average term. Table 2 summarizes participants' responses to this question.

**Table 2. Technologies used by teachers.**

| Participant | Technologies |
|---|---|
| Teacher 1 | Computers, Internet |
| Teacher 2 | Computer, Software Packages |
| Teacher 3 | Smart boards, Computers, Internet, Software |
| Teacher 4 | Smart Boards, iPads |
| Teacher 5 | Computers and Laptops, Websites and Blogs, |
| Teacher 6 | Smart Boards, Internet, Educational Games |
| Teacher 7 | Computer, iPads |
| Teacher 8 | Smart board, Internet, Blogs. |
| Teacher 9 | iPads, Smart Board, Computers |
| Teacher 10 | Team Board, Computer, iPad, Computer lab |
| Teacher 11 | No Response |

Figure 2 shows the proportion of time that participants integrate technologies into their teaching activities.

9. What proportion of time on average do you use digital technologies in your lessons?
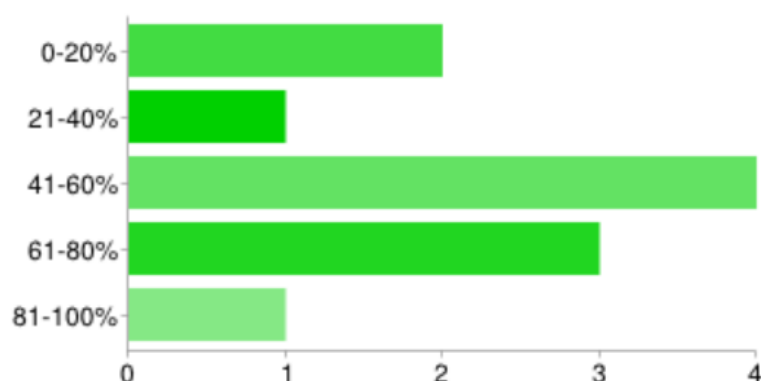


**Figure 2. Participants' responses regarding the average usage of digital technologis in their classrooms.**

In response to the next question (Question 10), regarding participants' proficiency levels in relation to robotics technology, nine participants (82 %) stated that they are unfamiliar with robotics and have no experience in working with robotics technology, while two participants (18%) stated that they are newcomers; they have attempted to use robotics technologies, but they still require help on a regular basis (Table 3).

**Table 3. Teachers' proficiency levels in relation to robotics technology.**

| Proficiency levels | Number (and Percentage) of Participants (%) |
|---|---|
| Unfamiliar: I have no experience with robotics technologies. | 9 (82%) |
| Newcomer: I have attempted to use robotics technologies, but I still require help on a regular basis. | 2 (18%) |
| Beginner: I am able to perform basic functions in a limited number of robotics applications. | --- |

| Average: I demonstrate a general competency in a number of robotics applications | --- |
|---|---|
| Advanced: I have acquired the ability to competently use a broad spectrum of robotics technologies. | --- |
| Expert: I am extremely proficient in using robotics technologies. | --- |

## 4.3. Survey Section 3: The Process of Integration of Robotics

The first question in this section was used to determine participants' experience with using robotics in their teaching activities. All the participants stated that they have never employed robotics for teaching. Furthermore, 10 participants stated that they had not received any pre-service/in-service training for employing robotics as an educational tool, while one of them stated that she had received a full day or less training. Seven participants (64%) stated that they need more than one-semester training if they want to integrate robotics into their teaching, while two participants (18%) perceived to need more than a full day and less than a one-semester course (Figure 3).



**13. If applicable, please indicate the total amount of Pre-service/In-service training you "need" to use robotics technology in the classroom:**
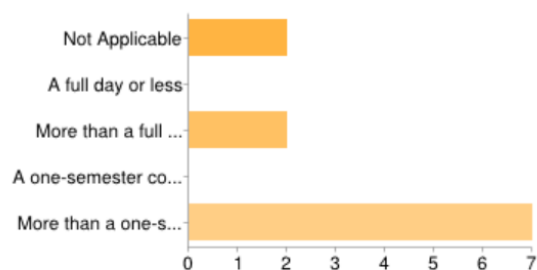
**Figure 3. Participants' perceptions of the total amount of training they need.**

In Question 14, the participants were presented with descriptions of six stages related to the process of integrating robotics into teaching activities. The participants were asked to indicate the stage that best describes them. Ten participants stated that they are aware

that robotics exists, but have not used it. They stated that perhaps they are even avoiding

it and are anxious about the prospect of using robotics. However, one participant stated

that she is currently trying to learn the basics; she is sometimes frustrated using robotics

and she lacks confidence when using it (Table 4).

**Table 4. Six stages of the process of integrating robotics into teaching.**

| Descriptions of each of stages | Number (and Percentage) of Participants (%) |
|---|---|
| Awareness: I am aware that robotics exists, but have not used it – perhaps I'm even avoiding it. I am anxious about the prospect of using robotics. | 10 (91%) |
| Learning: I am currently trying to learn the basics. I am sometimes frustrated using robotics and I lack confidence when using them. | 1 (9%) |
| Understanding: I am beginning to understand the process of using robotics technology and can think of specific tasks in which it might be useful. | --- |
| Familiarity: I am gaining a sense of self-confidence in using robotics for specific tasks. I am starting to feel comfortable using the robotics. | --- |
| Adaptation: I think about robotics as an instructional tool to help me and I am no longer concerned about it as technology. I can use many different robotics applications. | --- |
| Creative Application: I can apply what I know about robotics in the classroom. I am able to use it as an instructional aid and have integrated robotics into the curriculum | --- |
| Awareness: I am aware that robotics exists, but have not used it – perhaps I'm even avoiding it. I am anxious about the prospect of using robotics. | --- |

While six participants did not answer the next question regarding the methods that

they used to gathered information about educational robots, Teacher 1, Teacher 2, and

Teacher 5 stated that they have gained this knowledge from media and the internet or by

reading some documents about robotics and robotics competitions. Furthermore, teacher

9 stated that she has no knowledge about robotics and teacher 10 sated that she has

gained this knowledge from the videos that the researcher had provided the participants.

In response to Question 15, seven participants (64%) claimed that they think robotics is a useful educational tool for primary/elementary grades, while four participants (36%) expressed that they are not sure about the usefulness of integrating robotics in primary/elementary schools (Figure 4).

**15. Do you think it would be useful to use robotics technology in primary/elementary schools?**
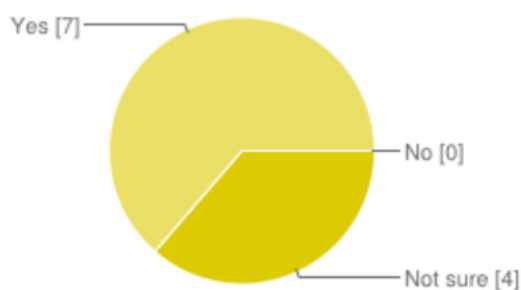


**Figure 4. Teachers' perceptions of the usefulness of integrating robotics in primary/elementary schools.**

The participants were also given the opportunity to provide comments in follow up to Question 15. While Teacher 1 perceived robotics might be useful for high school students, he/she was unsure about the effectiveness of using robotics in primary/elementary schools and thought primary/elementary students may not learn robotics. Teacher 3 was unable to declare whether or not robotics is an effective educational tool for primary/elementary grades, due to the lack of knowledge about robotics. However, Teacher 2 stated that as robotics is a lovely tool for primary/elementary students, it may help students to love schools. Furthermore, Teacher 4 stated that "[s]tudents at this age enjoy learning new things and they have no fear experimenting with technologies. Robotics can teach them so many outcomes without children even realizing it."

In Question 16, a number of potential obstacles that may prevent primary/elementary teachers from using robotics technology into their teaching activities were listed and the participants indicated whether they perceive these factors as obstacles or not. Table 5 shows participants' responses to these questions.

Table 5. Potential obstacles that may prevent primary/elementary teachers from using robotics technology.

| | % participants indicated as | | | | |
|---|---|---|---|---|---|
| | Major obstacle | Small obstacle | Not an obstacle | I am not sure | No response |
| Usually there are not enough educational robots available in primary/elementary schools. | 91 | -- | -- | -- | 9 |
| Usually teachers do not have access to adequate and relevant software/hardware in primary/elementary schools. | 91 | -- | -- | -- | 9 |
| It is too difficult to schedule time in primary/elementary school's robotics projects to do the assignments. | 45 | 36 | 9 | -- | 9 |
| There are not enough computers available in primary/elementary schools to program the robots | 9 | 64 | -- | 18 | 9 |
| primary/elementary students are too young to be able to understand robotics and work with robots. | 9 | 18 | 64 | -- | 9 |
| There is too much course material and many subjects to cover in a year to have time for robotics | 55 | 18 | 18 | -- | 9 |
| Usually primary/elementary teachers are not sure how to make robotics technology relevant to their subject. | 64 | 18 | 9 | -- | 9 |
| Teachers need to prepare students for the stated outcomes and mandated | 45 | 9 | 27 | -- | 18 |

| | | | | | |
|---|---|---|---|---|---|
| tests, while using robotics does not prepare them for these tests and outcomes | | | | | |
| Usually primary/elementary teachers do not feel confident enough in their technology skills to use robotics in their classes | 82 | 9 | -- | -- | 9 |
| primary/elementary teachers do not have adequate administrative support | 9 | 27 | 45 | -- | 18 |
| Teachers do not have adequate technical support. | 73 | 18 | -- | -- | 9 |
| Teachers do not have adequate instructional support | 64 | 27 | -- | -- | 9 |

In addition, three participants added some notes, regarding other obstacles of using robotics in teaching activities. Teacher 1 perceived many primary/elementary teachers do not feel confident to integrate robotics into their teaching activities, because it is a very high-tech device. Teacher 2 perceived educational robotics to be a very expensive tool, so she believed many students are not able to buy such an expensive tool. Finally, Teacher 9 stated that "exposure to robotics" would be another obstacle.

In response to the question regarding kinds of support that teachers need in order to employ robotics in primary/elementary schools, the participants stated that they need the following support (Table 6):

**Table 6. Support that primar/elementary teachers need in order to employ robotics.**

| Participant | Support |
|---|---|
| Teacher 1 | An expert teaching assistant |
| Teacher 2 | Technical support, Pre-service/In-Service training |
| Teacher 3 | Technical and instructional support |
| Teacher 4 | Technical support, Team leader, Material, and Equipment. |
| Teacher 5 | Curriculum guides |

| Teacher 6 | Instructional and Technical support. |
|---|---|
| Teacher 7 | No response |
| Teacher 8 | Materials and guides, Technical support |
| Teacher 9 | Professional Development |
| Teacher10 | In-service, technical support, materials |
| Teacher11 | No response |

Table 7 shows the participants' responses to Question 17, which was a 5-point Likert

Scale question regarding the potential benefits of using robotics in teaching activities.

Table 7. Participants' responses regarding the potential benefits of using robotics in teaching activities.

| | % participants indicated as | | | | | |
|---|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | No response |
| a) Robotics has the potential to facilitate learning of mathematics in primary/elementary schools | -- | -- | 55 | 18 | 18 | 9 |
| b) Robotics has the potential to facilitate learning of science subjects in primary/elementary schools | -- | -- | 9 | 27 | 55 | 9 |
| c) Robotics has the potential to improve technology literacy in primary/elementary schools | -- | -- | -- | 9 | 82 | 9 |
| d) Using robotics in primary/elementary schools can help students to become lifelong learners | -- | -- | 9 | 9 | 73 | 9 |
| e) Using robotics in primary/elementary schools can help students in the process of scientific inquiry, and improve their skills of initiating and planning, performing and recording, analysing and interpreting. | -- | -- | 36 | 18 | 27 | 18 |
| f) Using robotics in primary/elementary schools can develop positive attitude about STEM disciplines | -- | -- | -- | 55 | 36 | 9 |
| g) Using robotics in primary/elementary schools can encourage students to pursue their education and | -- | -- | 18 | 18 | 27 | 36 |

| | | | | | |
|---|---|---|---|---|---|
| career in STEM-related fields | | | | | |
| h) Using robotics in primary/elementary mathematics helps students to improve their mathematical reasoning and problem solving skills | -- | -- | 18 | 27 | 18 | 36 |
| i) Using robotics in primary/elementary science subjects helps students to improve their communication and team work skills. | -- | -- | -- | 9 | 82 | 10 |
| j) Overall, students are actively involved in the lesson/unit than they are with comparable lessons/units that do not involve robotics technology. | -- | 9 | -- | 55 | 18 | 18 |
| k) Overall, students work together more than they do on comparable lessons/units that do not involve robotics technology | -- | 9 | -- | 45 | 27 | 18 |
| l) Overall, students' different learning styles are better accommodated than they are with comparable lessons/units that do not involve robotics technology. | -- | -- | 36 | 18 | -- | 45 |
| m) Overall, student work showed more in-depth understanding of content than in comparable lessons/units that do not involve robotics technology. | -- | -- | 27 | 27 | -- | 45 |
| n) Overall, student work is more creative than in comparable lessons/units that do not involve robotics technology. | -- | 9 | 18 | 36 | -- | 36 |
| o) Overall, students are able to communicate their ideas and opinions with greater confidence than in comparable lessons/units that do not involve robotics technology. | -- | 9 | -- | 36 | 45 | 9 |
| p) Overall, students help one another more than they do on comparable lessons/units that do not involve technology. | -- | 9 | 18 | 27 | -- | 45 |

In Questions 17.1 and 17.2, the participants were asked to give some examples of primary/elementary mathematics subjects which might be taught using robotics, and to explain how robotics can help students to learn these subjects. Although Teacher 2 provided some examples of mathematics subjects that can be taught using robotics, she expressed she is unable to claim that robotics can facilitate learning of mathematics in general. However, she stated that robotics can help students to visualize the orientation and movement of objects; therefore, robotics is a useful tool for teaching motion geometry, orientation and movement of objects. Teacher 4 claimed that geometry patterns, addition, subtraction, multiplication, and division can be taught using robotics. However, this participant could not explain how robotics facilitates learning of these topics: "[n]ot sure but I am sure with more knowledge of robotics it would work." Teacher 5 stated that mathematics subjects such as geometry (e.g. 2-D and 3-D) and measurement (e.g. measuring length and relationship between second and minute) can be taught using robotics, because her husband has easily taught these subjects to their son, using LEGO Mindstorm. Furthermore, Teacher 6 claimed that robotics might be useful to teach multiplication, numbers (e.g. how far, how long), shape, and space. Although Teacher 9 stated that she is not sure about the subjects that can be taught using robotics because she has not enough knowledge about robotics, she claimed robotics is useful for teaching measurement and geometry subjects. Finally, Teacher 10 perceived that robotics can be integrated into geometry.

In response to the questions regarding science topics which might be taught using robotics (Questions 17.3 and 17.4), Teacher 2 stated that some topics such as series and

parallel circuits from the grade 6 science curriculum can be taught using robotics,

because robots include some electrical circuits that can provide an opportunity for

students to compare series and parallel circuits and examine how electricity in circuits

can produce motion, light, and sound. Based on the examples that Teacher 3 provided,

some topics such as force and simple machines can be taught using robotics and students

can examine the effects of force and friction on the movement of objects. In addition,

Teacher 5 and Teacher 7 stated that motion, relative position, and physical science might

be taught using robotics. Although Teacher 8 was not sure about the topics that might be

taught using robotics and was unable to provide examples of such areas, she claimed she

perceives robotics as a useful tool for teaching science. Moreover, Teacher 9 stated that

robotics can help students to learn force (e.g. push/pull) and matter (e.g. liquids and

solids). Finally, Teacher 10 stated that robotics might be useful for teaching structures

because robotics provides an opportunity for students to build "strong structures using

necessary elements." This participant also stated that robotics helps teachers to present

different types of forces and the ways they may affect something; therefore, she

perceived robotics an effective tool for teaching invisible forces.

In the next two questions, the participants were asked to give some examples of any

other subjects in primary/elementary schools which might be taught using robotics, and

explain why they think robotics can be used for teaching these topics. However, only

Teacher 10 responded to these two questions. She stated that robotics helps students in

language arts, because they can write about and discuss their projects.

The aim of Questions 17.7 and 17.8 was to realize the effects of robotics on developing positive attitudes toward STEM disciplines. Teacher 2 claimed that robotics can convince students that STEM-related subjects can be fun, so robotics can develop positive attitudes about STEM disciplines in primary/elementary students. Teacher 4 stated that robotics has the potential to encourage primary/elementary students to pursue their education or career in STEM-related disciplines, because students "would know if this is an area of learning that they excel and enjoy." Furthermore, Teacher 5 perceived robotics as an interesting tool that can help students to love technical and difficult subjects, such as science and mathematics. Teacher 8 claimed that robotics can attract students to STEM-related subjects, because it provides an environment for students to learn STEM subjects when playing with robots. Teacher 9 and Teacher 10 perceived robotics as new motivational technology that provides students with new exciting ways of learning: "students have interest in new things. Robotics would provide students with a new way to learn old concepts" (Teacher 9). Teacher 10 stated that "motivational activities for sure which make something appealing and interesting to children."

The participants were asked to explain how robotics might help primary/elementary students to improve their mathematical reasoning and problem solving skills. Teacher 4 stated that robotics can assist students in mathematical reasoning and problem solving, because "[t]hinking process to build and plan provides reasoning and problem solving skills." Also, Teacher 9 stated that robotics provides an opportunity for students to "explore various solutions as a small group", and "explore new things and solve problems

along the way." Finally, Teacher 10 stated that students "would be motivated to make something operate and that would certainly encourage problem solving."

In Question 17.10 the participants were asked to explain how robotics in primary/elementary schools might help students to improve their communication and teamwork skills. Teacher 2, Teacher 3, Teacher 4, Teacher 5, and Teacher 9 believed that the teamwork nature of robotics provides an opportunity for students to share their ideas with other team members, so that it would help students to develop their communication skills, as well as teamwork abilities. For instance, Teacher 9 stated that "[i]n order to be successful in robotics, students would have to work as a small group and develop their communication skills so that that entire group."

Question 17.11 asked the participants to explain how robotics in primary/elementary schools might improve students' scientific inquiry skills, such as skills of initiating and planning, performing and recording, analysing and interpreting. While Teacher 10 stated that "these seem to all be necessary skills in creating something that has to perform a function," Teacher 9 claimed the teamwork nature of robotics helps students to develop these skills.

Table 8 shows the participants' responses to Question 18, regarding the resources that school administrations should provide teachers in order to improve their instructional use of robotics.

**Table 8. the resources that school administrations should provide teachers.**

| Participant | Required resources |
|---|---|
| Teacher 1 | Technical support, Up-to-date documents, Tools and software packages. |
| Teacher 2 | Training, Dedicated robots |
| Teacher 3 | No response |
| Teacher 4 | No response |
| Teacher 5 | Instructional resources |
| Teacher 6 | No response |
| Teacher 7 | No response |
| Teacher 8 | Leaders and instructional resources |
| Teacher 9 | Professional development |
| Teacher 10 | In-service technology, Technical support , Space |
| Teacher 11 | No response |

## 4.4 Survey Section 4: Overall Perceptions

In Question 19, the participants were provided with 41 short statements about their perceptions of using educational robotics. The participants were free to choose as many options that they perceived to be correct. Table 9 shows the participants response rates to these questions:

**Table 9. Participants overall perceptions.**

| Statement | Response rate (%) |
|---|---|
| Increases academic achievement (e.g. grades). | 45 |
| Increases student proficiency in collaboration. | 82 |
| Increases student proficiency in data analysis. | 36 |
| Increases student proficiency in presenting to an audience. | 55 |
| Increases student proficiency in research. | 45 |
| Prepares students for future jobs. | 64 |
| Supports student remediation in basic skills such as math and reading. | 18 |
| Enables students to express their ideas and opinions. | 82 |
| Improves student test scores. | 27 |
| Promotes active learning strategies. | 64 |

| | |
|---|---|
| Satisfies parents and community interests. | 27 |
| Improves your own productivity and efficiency. | 27 |
| Results in students neglecting important traditional learning resources (e.g., library books). | 9 |
| Is effective because I believe I can implement it successfully. | 0 |
| Promotes student collaboration. | 91 |
| Makes classroom management more difficult. | 18 |
| Promotes the development of communication skills (e.g., sharing ideas and presentation skills). | 82 |
| Is a valuable instructional tool. | 64 |
| Is too costly in terms of resources, time and effort. | 64 |
| Is successful only if teachers have access to robotics technology. | 64 |
| Makes teachers feel more competent as educators. | 9 |
| Is successful only if there is adequate teacher training in the use of robotics technology for learning. | 73 |
| Gives teachers the opportunity to be learning facilitators instead of information providers. | 27 |
| Demands that too much time be spent on technical problems. | 73 |
| Is successful only if there is the support of parents. | 9 |
| Is an effective tool for students of all abilities. | 9 |
| Enhances my professional development. | 27 |
| Eases the pressure on me as a teacher. | 9 |
| Motivates students to get more involved in learning activities. | 73 |
| Increase students interest towards Science, Technology, Engineering, and Mathematics (STEM) disciplines. | 82 |
| Limits my choices of instructional materials. | 0 |
| Requires Hardware/Software-skills training that is too time consuming. | 64 |
| Promotes the development of students' interpersonal skills (e.g., ability to relate or work with others). | 64 |
| Will increase the amount of stress and anxiety students experience. | 0 |
| Is difficult because some students know more about robotics than many teachers do. | 36 |
| Is only successful if robotics technology is part of the students' home environment. | 0 |

| | |
|---|---|
| Requires extra time to plan learning activities. | 73 |
| Improves student learning of critical concepts and ideas. | 45 |
| Becomes more important to me if the student does not have access to a robot at home. | 0 |
| Increases my workload in the short term | 64 |
| Increases my workload in the long term | 9 |

Finally, in Question 20 the participants were asked to add their overall opinion about using robotics for teaching STEM-related subjects in primary/elementary schools. Teacher 4 stated that "it would be fabulous to implement. Young minds love the challenge and fun of learning through hands on activities." Teacher 6 stated that the website was helpful; however, she claimed if the researcher could provide her with a real robot, she would be able to respond to the questions more accurately. Teacher 7 expressed that robotics is an interesting educational tool and she likes to integrate robotics in her teaching activities. Finally, Teacher 9 stated that "I would love to try it in my classroom. However, there is a lot of learning on my part that would have to happen before."

## 4.5 Data analysis
The research questions addressed in this study include:

1. To what extent do the primary/elementary teachers agree that robotics can help students to learn STEM subjects?

2. To what extent do teachers believe that robotics can improve students' lifelong learning skills (e.g. team working, problem solving)?

3. To what extent do teachers believe that robotics can help primary/elementary students develop positive attitudes toward STEM disciplines and encourage them to pursue their education and career in these fields?

4. What do teachers believe are the barriers of using robotics in primary/elementary schools?

5. What supports do teachers perceive they need to integrate robotics into their curricula?

In order to address the research questions, the analysis of the data revealed two main themes: (1) the effects of robotics on STEM education, and (2) teachers' barriers and the support they need to overcome the barriers.

## 4.5.1 Effects of Robotics on STEM Education

A review of the literature demonstrates that the aim of STEM education is to help students to: 1) further their knowledge in these disciplines, 2) help students to become lifelong learners, and 3) promote students' interest toward STEM disciplines and encourage them to pursue education and careers in STEM-related fields. Therefore, the perceived effects of robotics on STEM education are examined in the same three sub-themes, including:

1. Effects of robotics on learning STEM subjects.

2. Effects of robotics on students' lifelong learning skills (e.g. teamwork, problem solving).

3. Effects of robotics on promoting students' interest toward STEM disciplines.

**4.5.1.1 Effects of Robotics on Learning STEM Subjects**

This emerging theme shows that (1) robotics has the potential to facilitate learning of science and technology, and (2) there is not enough evidence that robotics might be useful for teaching mathematics or engineering subjects. The analysis of data revealed that the majority of the participants agreed that robotics is a useful tool for teaching science subjects in primary/elementary schools. Almost all the participants agreed that robotics has the potential to improve technology literacy in primary/elementary schools. However, it is surprising that the participants did not perceive that robotics can increase students' academic achievement and test scores. Surprisingly, although some participants provided some examples of mathematics subjects that can be taught using robotics and stated that robotics can help students to improve their mathematical reasoning, the majority of participants were not convinced that robotics facilitates learning of mathematics subjects.

Overall, the data analysis shows that robotics is considered a useful tool for teaching science and technology disciplines and has the potential to facilitate learning of these subjects because it promotes active learning strategies and motivates students to get more involved in learning activities. However, the participants did not perceive robotics to be a useful educational tool for teaching these subjects to students of all abilities.

**4.5.1.2 Effects of Robotics on Students' Lifelong Learning Skills**

This emerging sub-theme shows that robotics has positive effects on students' lifelong learning skills. Almost all the participants agreed that robotics can develop students' interpersonal skills and help primary/elementary students to become lifelong learners.

Specifically, the majority of participants agreed that robotics has the potential to improve students' collaboration and teamwork abilities. Robotics was also perceived by participants to have positive effects on students' communication skills, their abilities to share their ideas with others, and present their findings to audiences. While two participants out of the seven who responded to the question regarding the effects of robotics on mathematical reasoning and problem solving skills felt neutral, five other responders agreed or strongly agreed that robotics has a positive effect on the above mentioned skills. Therefore, the participants' responses suggest that the participants considered robotics an effective tool for improving mathematical reasoning and problem solving.

Four participants out of the nine who responded to the question regarding the effects of robotics on improving skills of initiating and planning, performing and recording, and analysing and interpreting felt neutral while five other participants agreed or strongly agreed that robotics has positive effects on the above mentioned skills. Therefore, it can be concluded that these teachers perceived that robotics has positive effects on scientific inquiry skills. The participants also perceived that students in robotics classes help one another more than they do on comparable lessons/units that do not involve robotics technology.

**4.5.1.3 Effects of Robotics on Promoting Students Interests Toward STEM Disciplines**

Almost all the participants agreed that robotics can attract students toward STEM disciplines. Five participants out of the seven who responded to the question regarding

the effects of robotics on STEM-related careers agreed that robotics has a positive effect on this item. Therefore, this sub-theme suggests that primary/elementary teachers perceived robotics as an effective tool that helps students to develop positive attitudes toward STEM disciplines. Also, according to this sub-theme, robotics can encourage students to pursue their education and career in STEM-related fields and prepares them for future jobs.

### 4.5.2 Teachers' Barriers and the Support They Need

This theme shows that the most challenging factor that may prevent primary/elementary teachers from using robotics technology in their teaching activities is the lack of access to supporting materials. Almost all the participants believed that the lack of enough educational robots and adequate software/hardware is the major obstacle of using robotics in primary/elementary schools. Furthermore, the majority of participants believed that inadequate technical support, teachers' lack of confidence in their technology skills, and their lack of knowledge in making connection between robotics and the subject matter are also major obstacles. Other challenges that may prevent primary/elementary teachers from using robotics include: the work-load, the lack of preparation time and classroom time, and inadequate instructional support. The majority of the participants believed that robotics does not prepare students for the many mandated outcomes and tests. Therefore, primary/elementary teachers might be reluctant to integrate robotics into their teaching activities because they perceive robotics as an unnecessary topic. Also, robotics is perceived to be too costly a subject in terms of resources, time and effort. It requires extra time to plan learning activities, consumes too

much time for training and dealing with technical problems, and increases teachers'
workload in the short term. The majority of participants perceived that they need
technical and instructional support, pre-service and in-service training,
hardware/software-skills training, and access to adequate robotics technology in order to
be able to integrate robotics into their teaching activities.

**4.6 Discussion and Conclusion**

The results of this study indicate that robotics is perceived by primary/elementary
teachers to be a useful tool for teaching and learning science and technology. Therefore,
this study concurs with Barker and Ansorge (2007), Bers and Portsmore (2005), Bers et
al. (2002), Carberry and Hynes (2007), Cooper et al. (1999), Grubbs (2013), Martin
(1996), Nugent et al. (2010), Rogers and Portsmore (2004), and  Williams et al. (2007)
regarding the positive effects of robotics on learning science and technology.
Specifically, the participants concur with Johnson (2002) and Grubbs (2013) that robotics
can facilitate learning of electronics subjects such as electron flow and series and parallel
circuits. Also, like Chambers et al. (2007), Gura (2012), and Johnson (2002) the
participants perceive that robotics can be integrated into science curriculum to teach force
and motion. However, it is surprising for the researcher that the majority of participants
perceive robotics has no positive effects on students' academic achievement and test
scores.

Overall, the results of this study suggest that teachers do not perceive that robotics can
facilitate learning of primary/elementary mathematics. Therefore, this study does not
concur with the studies that indicate robotics facilitates learning of mathematics subjects

(e.g. Allen, 2013; Bers & Portsmore, 2005; Cooper et al., 1999). One potential reason for this result could be the participants' lack of knowledge about robotics. For instance, in response to Questions 17.1 and 17.2, regarding the effects of robotics on learning mathematics, one of the participants stated, "I'm not sure I have enough knowledge about robotics to answer this question." Surprisingly, while the participants do not perceive robotics to be a useful tool for learning mathematics, they perceive that robotics has the potential to improve students' lifelong learning skills. Newfoundland and Labrador mathematics documents clearly stated that the goal of mathematics is not only to learn mathematics topics, but also to "embrace lifelong learning in mathematics" (Newfoundland and Labrador Department of Education, 2009, p. 5). In order to achieve this goal, education system should create an environment that students encounter 7 critical components, including reasoning, problem solving, and communication skills which are called components of *mathematical processes* (Newfoundland and Labrador Department of Education, 2009). It is surprising that the majority of participants do not see a connection between robotics and learning mathematics, while they perceive robotics has positive effects on these components of mathematical processes. It can be interpreted that teachers focus more on teaching mathematics content rather than improving the related skills. Therefore, it can be concluded that not only the lack of knowledge about robotics, but also incomplete information about mathematics' outcomes and objectives prevents the participants to make a connection between mathematics and robotics. However, some study participants concur with the existing literature regarding the positive effects of robotics on learning mathematics subjects. Specifically, some participants agree with Allen (2013), Brosterman (1997), Gura (2012), Johnson (2002),

and Samuels and Haapasalo (2012) that robotics helps students to learn numbers, sizes, shapes, and geometry.

The existing literature shows that robotics facilitates learning of subject matter because it: (a) provides visual and hands-on activities, (b) immerses students in problem solving through Problem-Based Learning, and (c) provides an opportunity for students to connect the lessons with their real-lives and their prior knowledge. Although one of the participants in this study stated that robotics provides visual activities for learning mathematics subjects, no other participants mentioned this factor. The participants also indicated that robotics improves students' problem solving skills; however, they did not indicate this improvement as a factor that may facilitate learning of subject matter. Surprisingly, none of the participants stated that robotics helps students to learn the subject matter by connecting the lessons with students' real-lives and prior experiences. This result shows that robotics is not well-known for the participants that they do not recognize any connection between robotics and real word problems. Therefore, the responses from participants did not provide enough evidence to consider these three factors as the reasons for the effectiveness of robotics for teaching subject matter in primary/elementary grades.

A review of literature demonstrated that robotics can improve students' problem solving skills (Bers & Portsmore, 2005; Chalmers et al., 2012; Clements et al., 2001; Eguchi; 2007; Faisal et al., 2012; Gura, 2012; Highfield, 2010;  Whitehead, 2010). The results of this study concur with the existing literature regarding the positive effects of robotics on students' problem solving skills because the majority of participants perceive

that robotics has the potential to improve primary/elementary students' problem solving skills. Based on the existing literature, robotics also can improve interpersonal skills, including collaboration and teamwork (e.g. Grubbs, 2013; Gura, 2012), communication skills, and the ability to share ideas (e.g. Atman et al., 2008; Bers, 2007; Chambers et al., 2007; Eguchi, 2007; Faisal et al., 2012; Grubbs, 2013; Gura, 2012; Resnick, 2003). The results of this study also show that robotics is perceived by primary/elementary teachers to be a useful tool for improving students' interpersonal skills. Therefore, this study supports the existing literature regarding the positive effects of robotics on interpersonal skills. This study is also in agreement with other studies (e.g. Cameron & Barrell, 2002; Eguchi, 2007) that robotics provides an opportunity for students to experience scientific processes.

A review of literature indicated that robotics is an engaging tool that improves students' attitudes and interests toward STEM subjects (Allen, 2013; Fagin & Merkle, 2003; Faisal et al., 2012; Johnson & Londt, 2010; Mauch, 2001; Robinson, 2005; Welch, 2010; Whitehead, 2010). Robotics also encourages students to pursue STEM-related majors and careers in future (Allen, 2013; FIRST, 2006; Grubbs, 2013; Ludi, 2012; Nugent et al., 2010; Nugent et al., 2011; Melchior et al., 2005; Welch & Huffman, 2011). The results of this study suggest that robotics can promote primary/elementary students' interests toward STEM-related subjects and has the potential to encourage students to pursue careers and studies related to STEM. Therefore, this study is in agreement with the reviewed literature.

The results of this study indicate a number of challenges and obstacles that teachers may encounter when integrating robotics into their teaching activities. As a challenge, the participants perceive robotics as an unnecessary topic that does not prepare students for many mandated outcomes. It can be interpreted that although the participants acknowledge that robotics is useful for teaching and learning some science and technology-related topics, they believe robotics is a time-consuming topic that may prevent teachers from covering all the mandated topics. In accordance with the existing literature (e.g. Alimisis, 2013; Bers & Portsmore's, 2005), the results of this study show that the obstacles and challenges include inadequate access to supporting materials, inadequate technical and instructional support, the lack of preparation time and classroom time, teachers' lack of knowledge about robotics, and their lack of confidence in their technology skills. The analysis of the data reveal that pre-service and in-service training is considered the most important support teachers perceive to be necessary. Most of the participants concur with the existing literature (e.g. Bers & Portsmore, 2005) that one semester in-service/pre-service training is not enough for them to be able to successfully integrate robotics into their teaching activities. Therefore, the participants perceive that they need more than one semester training. Also, a number of participants stated that they would need expert teacher assistants and team leaders; therefore, like Bers and Portsmore, the participants perceive *partnerships* a useful method of training. Materials, guides, and manuals are other types of support that teachers perceive to be necessary. One promising result of this study is that most of the participants are satisfied with administrative support and perceive they will receive adequate support from school administration if they want to integrate robotics into their teaching activities.

In addition to the emerging themes that are discussed above, the following results are extracted from the analysis of the data. The participants of this study claimed their access to educational technology to be above 60% and they frequently use a variety of technologies in their classes; however, all the participants stated that they have never employed robotics for teaching the subject matter. Even worse, most of the participants stated that they are unfamiliar with robotics and they have no experience with robotics technology (in general, not for educational purposes). Hence, the results of this study reveal that robotics is unknown for some Newfoundland and Labrador primary/elementary educators, although the majority of participants agree with the existing literature that robotics is a useful educational tool. Also, the majority of participants do not agree that primary/elementary students are too young to be able to work with robots and understand robotics; therefore, the results of this study support the existing literature that no age is too young to be engaged by robots. Most of the participants also agree that robotics provides an opportunity for primary/elementary students to be actively involved in the lesson activities. Thus, this study provides another example that robotics supports constructivism theory by giving an active role to students. The existing literature (e.g. Werry et al., 2001) demonstrates that robotics is a useful tool for all students and children with special and cognitive needs are motivated by robots. However, the results of this study are not in agreement with the existing literature as the participants do not perceive that robotics is a useful learning tool for students of all abilities. It seems the participants perceive robotics as a very difficult subject that only some students (probably only talented students) are able to learn. Moreover, the analysis

of the data revealed that teachers perceive students' work would be more creative and would show more in-depth understanding if teachers integrated robotics into the lessons.

## 4.7 Limitation of the Study

Due to the participation issues, the data collected in this study came from a relatively small number of participants; therefore, the ability to generalize the results is limited. Although the researcher preferred to gather data by interviewing the participants, all the participants preferred to participate in the study by completing an online survey. If the participants had participated in face-to-face interviews, the researcher would have had the opportunity to explain the questions or even ask the participants to explain their perceptions. For example, in response to the questions asking participants to rate student and teacher access to educational technology, Teacher 1 rated 75 to student access and 60 to teacher access and Teacher 10 rated 80 to student access and 90 to teacher access, while other participants indicated the same access rate for both teachers and students. It is important for the researcher to understand why these two participants think teachers and students do not have equal access to educational technology. However, the method of participation (i.e. online participation) did not allow the researcher and the participants to have interactive conversations, so the researcher was unable to ask the participants to clarify their responses. As none of the participants had previous experience integrating robotics into their teaching activities, the results regarding the effectiveness of robotics for STEM education may not be generalized. In fact, although the researcher introduced educational robotics to the participants by providing videos and a journal article via a website, the participants did not receive hands-on experience during the study. It has been

shown in the studies (e.g. Bers & Portsmore, 2005) that theoretical training is not enough; teachers first need to experience robotics technology themselves and be actively engaged in learning by design activities. Therefore, if participants had experienced using robotics in primary/elementary schools or if they had received hands-on training, the results would have had the potential to be generalized. Another limitation of this study is that the researcher was unable to ask participants questions regarding the effects of robotics on learning engineering-related subjects, because there is no engineering-related curriculum in primary/elementary grades. The researcher only examined the effects of robotics on learning science, technology, and mathematics; as a result, it cannot be concluded whether robotics is perceived to be a useful tool for learning engineering subjects in primary/elementary grades.

## 4.8 Suggestions for Future Research

Employing robotics technology in education is considered a new topic and there is a need for more in-depth research in this area. Based on this study, several topics are suggested for future research. Firstly, this study can be repeated by recruiting more participants which would give a better indication of perceptions of all teachers and would allow for general conclusions to be drawn. Secondly, the researcher should not rely on only a website for providing teachers with information about robotics. Some elementary teachers may be afraid of robotics (and even mathematics and science), so they may not try to learn it by themselves using a website. Also, it is very difficult for a teacher to express what kind of support he/she needs, if he/she has never worked with a robot and is not sure how a robot works. Therefore, it would be good to arrange professional

development training and provide participants with real educational robots before they respond to the questions. Thirdly, it would be worthwhile to collect data by interviewing participants rather than using online surveys because interviews would allow the researchers and the participants to have interactive conversations, and the researchers would have the opportunity to explain the questions or even ask the participants to explain their responses. Fourthly, the participants of this study included eight female teachers and three other teachers who preferred not to declare their gender; therefore, most of the participants of this study were female. Comparing female teachers' perceptions and male teachers' perceptions can be reckoned as an important and interesting area for future research. Therefore, this study can be repeated by recruiting only male teachers or even recruiting equal numbers of male and female teachers and comparing their perceptions. It is also important to realize whether robotics intervention changes teachers' perceptions or not. Thus, the fifth suggestion is to repeat this study by conducting pre-interviews followed by hands-on training and post-interviews. Finally, it would be worthwhile to conduct pre-interviews, then provide an opportunity for teachers to integrate robotics into their teaching activities, and then conduct post-interviews in order to compare teachers' perceptions with their experiences.

## 4.9 Summary

The purpose of this case study was to gather perceptions of teachers regarding the effect of robotics on STEM education in primary/elementary grades. The goal was to highlight experiences, ideas, perspectives, concerns, and issues which might have an impact on future design, implementation, and delivery of the use of robotics in

primary/elementary schools. This chapter presented the results of the online surveys and the analysis of the data. In general, the results of this study are not surprising because the results are supported by the existing literature; however, this study shows two surprising results that are not supported by the existing literature: (a) robotics has no effects on learning mathematics subjects, and (b) robotics is not a suitable learning tool for students of all abilities. In this chapter, a discussion of the results along with a discussion of limitations arising from this research and suggestions for further research is also presented.

**REFERENCES**

Ackerman, E. (2001). *Piaget's Constructivism, Papert's Constructionism: What's the difference?* Retrieved from

http://learning.media.mit.edu/content/publications/EA.Piaget%20_%20Papert.pdf

Adams, J. P., & Turner, S. (2008, July). *Problem solving and creativity for undergraduate engineers: Process or product?* Paper presented at the International conference on innovation, good practice and research in engineering education, Loughborough, UK. Retrieved from

http://www.engsc.ac.uk/downloads/scholarart/ee2008/p061-adams.pdf.

Adams, J., Kaczmarczyk, S., Picton, P., & Demian P. (2010). Problem solving and creativity in engineering: conclusions of a three year project involving reusable learning objects and robots. *Engineering Education*, *5*(2), 4-17. doi: 10.11120/ened.2010.05020004

Adolphson, K. (2005, October). *Robotics as a context for meaningful mathematics.* Paper presented at the annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Roanoke.

Alberta Education, (2007). *Mathematics kindergarten to grade 9*. Retrieved from

http://education.alberta.ca/media/645594/kto9math.pdf

Alimisis, D. (2013). Educational robotics: Open questions and new challenges. *Themes in Science & Technology Education, 6*(1), 63-71.

Alimisis, D. (2007). Robotics-enhanced constructivist learning: The TERECoP project. In *Proceedings of the 2007 RuraLEARN Conference and Workshops* (p. 207-213), Mesta, Chios, Greece.

Alimisis, D., & Kynigos, C. (2009). Constructionism and robotics in education. In D.

    Alimisis (Ed.), *Teacher education on robotics-enhanced constructivist*

    *pedagogical methods* (pp. 11-26). Athens: ASPETE.

Allen, K. C. (2013). Robots bring math-powered ideas to life. *Mathematic Teaching in*

    *the Middle School. 18*(6). 340-347.

Atman, C., Kilgore, D., & McKenna, A. (2008). Characterizing design learning: A

    mixed-methods study of engineering designers' use of language. *Journal of*

    *Engineering Education*, *97*(3), 309-326. http://search.ebscohost.com

Attard, C. (2012). Teaching with technology: Exploring the use of robotics to teach

    mathematics. *Australian Primary Mathematics Classroom, 17*(2), 31-32.

    Retrieved from http://eric.ed.gov/?id=EJ978138

Barak, M., & Doppelt, Y. (2000). Using a portfolio to enhance creative thinking. *The*

    *Journal of Technology Studies, 26*(2), 16–25.

Barak, M., & Zodak, Y. (2009). Robotics projects and learning concepts in science,

    technology and problem solving. *International Journal of Technology and Design*

    *Education*, *19*(3), 289-307.

Barker, B., & Ansorge, J. (2007). Robotics as means to increase achievement scores in an

    informal learning environment. *Journal of Research on Technology Education*,

    *39*, 229–243.

Bauerle, A., & Gallagher, M. (2003). Toying with technology: Bridging the gap between

    education and engineering. In C. Crawford et al. (Eds.), *Proceedings of Society*

    *for Information Technology & Teacher Education International Conference* 2003

    (pp. 3538-3541). Chesapeake, VA: AACE.

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A

    systematic review. *Computers & Education, 58*(3), 978-988.

Bers, M. U. (2007). Project InterActions: A multigenerational robotic learning

    environment. *Journal of Science Education and Technology*, *16*(6), 537–552. doi:

    10.1007/s10956-007-9074-2

Bers, M. U. (2008). *Blocks to robots: Learning with technology in the early childhood*

    *classroom.* New York, NY: Teacher's College Press.

Bers, M., & Portsmore, M. (2005). Teaching partnerships: early childhood and

    engineering students teaching math and science through robotics. *Journal of*

    *Science Education and Technology*, *14*(1), 59–74.

Bers, M., & Urrea, C. (2000). Technological prayers: parents and children exploring

    robotics and values. In A. Druin & J. Hendler (Eds.), *Robots for kids: Exploring*

    *new technologies for learning experiences* (pp 194–217). New York, NY: Morgan

    Kaufman.

Bers, M., Ponte, I., Juelich, K., Viera, A., & Schenker, J. (2002). Integrating robotics into

    early childhood education. *Information Technology in Childhood Education*

    *Annual,* pp 123–145.

Boaler, J. (2002). *Experiencing school mathematics: Traditional and reform approaches*

    *to teaching and their impact on student learning.* Lawrence Erlbaum Associates:

    Mahwah, New Jersey.

Brantlinger , E., Jimenez, R., Klingner , J., Pugach, M., & Richardson,V. ( 2005).

    Qualitative studies in special education. *Exceptional Children, 71*, 195–207.

Brosterman, N. (1997). *Inventing kindergarten.* New York, NY: H.N. Abrams.

Butler, M. (2008). Professional development for teachers using technology. *proceedings of the 7th WSEAS International Conference on Education and Educational Technology* (pp. 55-58).

Cameron, M., & Barrell, B. (2001). Integrating robotics into a grade 2 classroom: Making space for Robert. In Barrell, B. (Ed.). *Technology, teaching and learning: Issues in the integration of technology* (183-196). Calgary, Alberta: Detselig Enterprises Ltd.

Canadian association of science centre, (2010). *Youth STEM guidelines.* Retrieved from http://www.canadiansciencecentres.ca/?n=29-161-153&newsId=73

Canadian Child Care Federation and Canadian Language and Literacy Research Network, (2010). *Foundations for numeracy: An evidence-based toolkit for the effective mathematics teacher.* Retrieved from http://foundationsfornumeracy.cllrnet.ca/pdf/SY_NumeracyKit09_ENG.pdf

Cantrell, P., Pekcan, G., Itani, A., & Velasquez-Bryant, N. (2006). The effects of engineering modules on student learning in middle school science classrooms. *Journal of Engineering Education, 95*(4), 301.

Carberry, A., & Hynes, M. (2007). Underwater Lego robotics: Testing, evaluation & redesign. *Proceedings of the ASEE Annual Conference and Exposition*.

Carbonaro, M., Murry, H., & Chambers, J. (2007) Exploring Spur Gears through the use of LEGO Robotic Technology. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2007* (pp. 2720-2727). Chesapeake, VA: AACE.

Carbonaro, M., Rex, M., & Chambers, J. (2004b). Using LEGO robotics in a project-based learning environment. *Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, 6*(1). Retrieved from http://imej.wfu.edu/articles/2004/1/02/index.asp

Carbonaro, M., Rex, M., Chambers, J. (2004a). Exploring middle school children's problem solving during robot construction tasks. In R. Ferdig et al. (Eds.), *Proceedings of the society of information technology and teacher education* (4546-4550). Charlottesville, VA: AACE.

Castledine, A., & Chalmers, C. (2011). LEGO Robotics: An authentic problem-solving tool? *Design and Technology Education: An International Journal, 16*(3), 19-27.

Cejka, E., Rogers, C., & Portsmore, M. (2006). Kindergarten robotics: Using robotics to motivate math, science, and engineering literacy in elementary school. *International Journal of Engineering Education*, *22*(4), 711-722.

Chalmers, C. (2013, March). *Learning with FIRST LEGO League.* Paper presented at the Society for Information Technology and Teacher Education (SITE) Conference, New Orleans, Louisiana.

Chalmers, C., Chandra, V., Hudson, S., & Hudson, P. (2012). Preservice teachers teaching technology with robotics. In *Going for Gold! Reshaping teacher education for the future*, Australian Teacher Education Association (ATEA), Adelaide, S. Aust.

Chambers, J. M., Carbonaro, M., & Murray, H. (2008). Developing conceptual understanding of mechanical advantage through the use of Lego robotic technology. *Australasian Journal of Educational Technology*, *24*(4), 387-401.

Chambers, J., Carbonaro, M., & Rex, M. (2007). Scaffolding Knowledge Construction

    through Robotic Technology: A Middle School Case Study. *Electronic Journal*

    *for the Integration of Technology in Education, 6*, 55 – 70. Retrieved from

    http://ejite.isu.edu/Volume6/Chambers.pdf

Church, W., Ford, T., Perova, N., & Rogers, C. (2010, May). *Physics with robotics:*

    *Using LEGO MINDSTORMS in high school education*. Paper presented at the

    American Association of Artificial Intelligence Spring Symposium, Stanford

    University, California.

Clements, D. H., Battista, M. T., & Sarama, J. (2001). Logo and geometry. *Journal for*

    *Research in Mathematics Education Monograph Series, 10*.

Cooper, M., Keating, D., Harwin, W., & Dautenhahn, K. (1999). Robots in the

    classroom: Tools for accessible education. In C. Buhler & H. Knops (Eds.),

    *Assistive technology on the threshold of the new millennium* (pp. 448–452).

    Amsterdam: IOS Press.

Creswell, J. (1998). *Qualitative inquiry and research design: choosing among five*

    *traditions.* Thousand Oaks, CA: Sage.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five*

    *approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating*

    *quantitative and qualitative research* (4th ed.). New York: Pearson.

Cunha, F., & Heckman, J. (2007). The technology of skill formation. *American Economic*

    *Review, 97*(2), 31–47.

Davis, B, Sumara, D., Luce-Kapler, R. (2008). *Engaging Minds: Changing Teaching in Complex Times*. Taylor & Francis, NY.

De Walle, J. A. V., Folk, S., Karp, K. S., & Bay-Williams, J. M. (2011). *Elementary and middle school mathematics: Teaching developmentally.* Toronto, ON: Pearson Canada Inc.

Dopplet, Y., Mehalik, M., Schunn, C., Silk, E., & Krysinski, D. (2008). Engagement and achievements: A case study of design-based learning in a science context. *Journal of Technology Education*, *19*(2), 21-38.

Druin, A., & Hendler, J. (2000). *Robots for kids: Exploring new technologies for learning*. San Diego, CA: Academic Press.

Eguchi, A. (2007). Educational robotics for elementary school classroom. In R. Carlsen et al. (Eds.), *Proceedings of society for information technology & teacher Education international conference* (pp. 2542-2549). Chesapeake, VA: AACE.

Eisenberg, M. (2003). Mindstuff: Educational technology beyond the computer. *Convergence 9*(2), pp. 29–53.

Fagin, B., & Merkle, L. (2003). Measuring the effectiveness of robots in teaching computer science. *Proceedings of the 34rd SIGCSE technical symposium on computer science education.* Retrieved from http://portal.acm.org/citation.cfm?id=611994&coll=GUIDE&dl=GUIDE&CFID=11715560&CFTOKEN=40703716

Faisal, A., Kapila, V., & Iskander, M. G. (2012, June). *Using robotics to promote learning in elementary grades*. Paper presented at the 19th ASEE Annual

Conference & Exposit. Retrieved from

http://www.asee.org/public/conferences/8/papers/5480/view

Fiese, B. H., & Bickman, N. L. (1998). Qualitative Inquiry: An overview for pediatric

psychology. *Journal of Pediatric Psychology, 23*, 79-86.

FIRST. (October, 2006). *About FIRST - Impact.* Retrieved from

http://www.usfirst.org/about/impact.htm.

Fortus, D., Krajcik, J., Dershimer, R. C., Marx, R. W., & Mamlok-Naamand, R. (2005).

Design-based science and real-world problem solving. *International Journal of

Science* Education*, 855–879.

Gee, J. P. (2008). *Getting over the slump: Innovation strategies to promote children's

learning.* New York, NY: The Joan Ganz Cooney Center at Sesame Workshop.

Goldman, R., Eguchi, A., & Sklar, E. (2004). Using educational robotics to engage inner-

city students with technology. In *Proceedings of the Sixth International

Conference of the Learning Sciences (ICLS)* (pp. 214—221).

Grubbs, M. (2013). Robotics Intrigue middle school students and build STEM skills.

*Technology and Engineering Teacher*, *72*(6), 12-16. Retrieved from

http://eric.ed.gov/?id=EJ1006898

Gura, M. (2012). Lego robotics: STEM sport of the mind. *Learning and Leading with

Technology, 40*(1)*, pp. 12- 16. Retrieved from http://eric.ed.gov/?id=EJ991224.

Han, J. (2012). Emerging technologies: Robot assisted language learning. *Language

Learning & Technology, 16*(3), 1-9. Retrieved from

http://llt.msu.edu/issues/october2012/emerging.pdf

Harris, K., Marcus, R., McLaren, K., & Fey, J. (2001). Curriculum material supporting problem based teaching. *Journal of Research in Science and Mathematics, 101*(6), 310-318.

Heck, A., & Holleman, A. (2003). Walk like a mathematician: An example of authentic education. In Trinadifillidis, K. Hatzikiriakou (Eds.), *Proceedings of the 6th International Conference on Technology in Mathematics Teaching (ICTMT 6)* (pp. 380–387). Athens: New Technologies Publications.

Henderson, N. (1991). The art of moderating: A blend of basic skills and qualities. *Quirks Marketing Research Review.* Retrieved from http://www.quirks.com/articles/al991/19911209.aspx?searchID=83327&sort=5&pg=l

Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K., Human, P., Murray, H., Oliver, A., & Wearne, D. (1997). Problem solving as a basis for reform in curriculum and instruction: The case of mathematics. *Education Researcher, 25*, 12-21.

Highfield, K. (2010). Robotic toys as a catalyst for mathematical problem solving. *Australian Primary Mathematics Classroom*, *15*(2), 22-27. Retrieved from http://eric.ed.gov/?id=EJ891802

Houghton, W. (2004). *How can learning and teaching theory assist engineering academics?* School of Engineering - University of Exeter. Retrieved from: http://www.heacademy.ac.uk/assets/documents/subjects/engineering/learning-teaching-theory.pdf

Hung, D. (2002). Situated cognition and problem-based learning: Implications for learning and instruction with technology. *Journal of Interactive Learning Research*, *13*(4), 393-414

Hussain, S., Lindh, J., & Shukur, G. (2006). The effect of LEGO training on pupils' school performance in mathematics, problem solving ability and attitude: Swedish data. *Educational Technology & Society, 9*(3), 182-194.

Jacobson, M. J., & Wilensky, U. (2006). Complex systems in education: Scientific and educational importance and implications for the learning sciences. *Journal of the Learning Sciences*, *15*(1), 11-34.

Jadud, M., (2000). Teamstorms as a theory of instruction. *In Proceedings of the IEEE Systems, Cybernetics and Man 2000 (SMC2000)*, Hanover, NH.

Jeschke, S., Kato, A., & Knipping, L. (2008). The engineers of tomorrow: Teaching robotics to primary school children. *Proceedings of the SEFI 36th Annual Conference*, Aalborg, Denmark.

Johnson, J. (2002). Children, robotics, and education. In *Proceedings of the 7th International Symposium on Artificial Life and Robotics* (491 – 496).

Johnson, R. T., & Londt, S. E. (2010). Robotics competitions: The choice is up to you! *Techdirections, 69*(6), 16-20.

Johnson, S. D. (1995). Will our research hold up under scrutiny? *Journal of Industrial Teacher Education, 32*(3), 3-6.

Katehi, L., Pearson, G., & Feder, M. (Eds.). (2009). *Engineering in K-12 education.* Washington, D.C.: The National Academies Press.

Kazakoff, E. R., Sullivan, A., Bers, M. U. (2013). The effect of a classroom-based
intensive robotics and programming workshop on sequencing ability in early
childhood. *Journal of Early childhood Education, 41*, 245-255. doi:
10.1007/s10643-012-0554-5

Kilgore, D., Atman, C., Yasuhara, K., Barker, T., & Morozov, A. (2007). Considering
context: A study of first-year engineering students. *Journal of Engineering
Education*, *96*(4), 321-334.

Klassner, F., & Anderson, S. (2002). LEGO MindStorms: Not just for K–12 anymore.
*IEEE Robotics and Automation Magazine*, 12-18.

Kolberg, E., & Orlev, N. (2001). Robotics learning as a tool for integrating science-
technology curriculum in K-12 schools. *31st ASEE/IEE Frontiers in Education
Conference*. Reno, NV.

Kolodner, J. L., Crismond, D., Gray, J., Holbrook, J., & Puntambekar, S. (1998).
Learning by design from theory to practice. *In proceeding of the ICLS 98* (pp. 16-
22). Atlanta, GA.

Kolodner, J. L., Gray, J., & Fasse, B. (2002). Promoting Transfer through Case-Based
Reasoning: Rituals and Practices in Learning by Design™ Classrooms. *Cognitive
Science Quarterly, 1*.

Kolodner, J., Camp, P., Crismond, D., Fasse, B., Gray, J., Holbrook, J.,..., Ryan, M.
(2003). Problem-based learning meets case-based reasoning in the middle-school
science classroom: Putting learning by design(tm) into practice. *Journal of the
Learning Sciences*, *12*(4), 495. doi: 10.1207/S15327809JLS1204_2.

Lombardi, M. (2007). Authentic learning for the 21st century: An overview. *Educause Learning Initiative.* Retrieved from

http://net.educause.edu/ir/library/pdf/ELI3009.pdf

Ludi, S. (2012). Educational robotics and broadening participation in STEM for underrepresented student groups. In B. Barker, G. Nugent, N. Grandgenett, & V. Adamchuk (Eds.), *Robots in K-12 education: A new technology for learning* (pp. 343-361). Hershey, PA.

Madill, H., Campbell, R.G., Cullen, D.M.,Armour,M. A., Einsiedel, A. A., Ciccocioppo, A. L.,..., Coffin, W. L. (2007). Developing career commitment in STEM-related fields: myth versus reality. In R. Burke, M. Mattis, & E. Elgar (Eds.), *Women and minorities in science, technology, engineering and mathematics: Upping the numbers* (pp. 210–244). Northhampton, MA: Edward Elgar Publishing.

Markert, L. R. (1996). Gender related to success in science and technology. *The Journal of Technology Studies, 22*(2), 21–29.

Martin, F. (1996). *Kids learning engineering science using LEGO and the programmable brick.* Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

Marulcu, I. (2010). *Investigating the impact of a LEGO(TM)-based, engineering-oriented curriculum compared to an inquiry-based curriculum on fifth graders' content learning of simple machines.* Doctoral dissertation.

Mataric, M. J. (2004, March). Robotics education for all ages. In *proceedings of American Association for Artificial Intelligence Spring Symposium on Accessible, Hands-on AI and Robotics Education,* Palo Alto, CA.

Mataric, M.J., Koenig, N., & Feil-Seifer, D.J. (2007). Materials for enabling hands-on robotics and STEM education. In *AAAI Spring Symposium on Robots and Robot Venues: Resources for AI Education.*

Mauch, E. (2001). Using technological innovation to improve the problem solving skills of middle school students. *The Clearing House, 75*(4), 211–213.

Mac Naughton, G. & Hughes, P. (2009). *Doing action research in early childhood studies: A step by step guide.* New York, Open University Press.

Melchior, A., Cohen, F., Cutter, T., & Leavitt, T. (2005). More than robots: An evaluation of the FIRST robotics competition participant and institutional impacts. *FIRST*, Manchester, NH.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach.* San Francisco: Jossey-Bass.

Merriam, S.B. (1998). *Qualitative research and case study applications in education.* San Francisco: Jossey -Bass Publishers.

Metz, S. S. (2007). Attracting the engineering of 2020 today. In R. Burke, M. Mattis, & E. Elgar (Eds.), *Women and minorities in science, technology, engineering and mathematics: Upping the numbers* (pp. 184–209). Northampton, MA: Edward Elgar Publishing.

Miaoulis, I. (2001). Introducing engineering into the K-12 learning environments. *Environmental Engineering, 37*, 7–10.

Mosley, P., & Kline, R. (2006). Engaging students: a framework using LEGO robotics to teach problem solving. *Information Technology, Learning, and Performance Journal, 24*(1), 39–45.

Nagel, K., & Kolodner, J. L. (1999). *SMILE: Supportive multi-user interactive learning environment.* Poster presented at the Support of Collaborative Learning, Palo Alto, CA.

National Academy of Engineering, & National Research Council. (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: National Academy Press.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

National Research Council. (2011). *Successful K-12 STEM education.* Washington, DC. The National Academies Press.

Newfoundland and Labrador Department of education, (2002). *Elementary science curriculum: Grade 5*. Retrieved from http://www.ed.gov.nl.ca/edu/k12/curriculum/guides/science/elementary/gr5.pdf

Newfoundland and Labrador Department of education, (2009). *Grade 2 mathematics curriculum guide – interim.* Retrieved from http://www.ed.gov.nl.ca/edu/k12/curriculum/guides/mathematics/gr2_math_guide .pdf

Newfoundland and Labrador Department of education, (2013). *Program of studies*. Retrieved from http://www.ed.gov.nl.ca/edu/k12/curriculum/POS/Program_of_Studies_2013-14.pdf

Nova Scotia Department of education, (2003). *Public school programs*. Retrieved from http://www.ednet.ns.ca/pdfdocs/psp/psp_03_04_full.pdf

Nugent, G., Barker, B., Grandgenett, N., & Adamchuck, V. (2010). Impact of robotics and geospatial technology interventions on youth STEM learning and attitudes. *Journal of Research on Technology in Education, 42*(4), 391-408.

Nugent, G., Barker, B., White, A. & Grandgenett, N. (2011). The impact of robotics competitions on youth  STEM learning, attitudes and 21st century workplace skills. In T. Bastiaens & M. Ebner (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* (pp. 3614-3619). Chesapeake, VA: AACE.

Oppliger, D. (2002). Using FIRST LEGO league to enhance engineering education and to increase the pool of future engineering students. *32nd ASEE/IEEE Frontiers in Education Conference*, Boston, MA.

Papert, S. (1980). *Constructionism vs. instructionism.* Retrieved from http://www.papert.org/articles/const_inst/const_inst1.html.

Papert, S. (1992). *The children's machine*. New York: Basic Books.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3 ed.). Thousand Oaks: Sage.

Penner, D. E. (2001). Cognition, computers, and synthetic science: Building knowledge and meaning through modeling. In W. G. Secada, (Ed.), *Review of research in education* (pp. 1–35). Washington, DC: American Educational Research Association.

Petre, M., & Price, B. (2004). Using robotics to motivate 'Back Door' learning. *Education and Information Technologies, 9*(2), 147–158.

Piaget, J. (1972). Development and learning. In C. S. Lavatelli & F. Stendler (Eds.), *Reading in children behavior and development.* New York, NY: Hartcourt Brace Janovich.

Piaget, J. (1973). *To understand is to invent.* New York, NY: Grossman.

Piaget, J. (1977). *The children and reality: Problems of genetic psychology*. New York, NY: Penguin Books.

Prince Edward Island Department of education, (2007). *Canadian Studies 401A.* Retrieved from http://www.gov.pe.ca/photos/original/edu_sscurriculm.pdf

Puntambekar, S., & Kolodner, J.L. (1998). The design diary: Development of a tool to support students in learning science by design. In *Proceedings of ICLS 98* (230-236). Atlanta, GA.

Resnick, M. (2003). Playful learning and creative societies. *Education Update, 8*(6). Retrieved from http://web.media.mit.edu/~mres/papers/education-update.pdf

Resnick, M., Berg, R., & Eisenberg, M. (2000). Beyond black boxes: Bringing transparency and aesthetics back to scientific investigation. *The Journal of the Learning Sciences* 9, 7–30.

Resnick, M., Martin, F., Sargent, R., and Silverman, B. (1996). Programmable Bricks: Toys to Think With. *IBM Systems Journal 35*(3), 443-452.

Reynolds, A. J., Temple, J. A., Ou, S. R., Arteaga, I. A., & White, B. A. B. (2011). School-based early childhood education and age-28 well-being: Effects by timing, dosage, and subgroups. *Science, 333*(6040), 360–364.

Robinson, M. (2005). Robotics-driven activities: Can they improve middle school science learning? *Bulletin of Science, Technology & Society, 25*(1), 73-84.

Rogers, C., & Portsmore, M. (2004). Bringing engineering to elementary school. *Journal of STEM Education*, *5*, 17–28.

Sadler, P. M., Coyle, H. P., & Schwartz, M. (2000). Engineering competitions in the middle school classroom: Key elements in developing effective design challenges. *Journal of the Learning Sciences, 9*, 299–327.

Samuels, P. & Haapasalo, L. (2012). Real and virtual robotics in mathematics education at the school–university transition. *International Journal of Mathematical Education in Science and Technology, 43*(3), 285-301.

Satchwell, R., & Loepp, F. L. (2002). Designing and implementing an integrated mathematics, science, and technology curriculum for the middle school. *Journal of Industrial Teacher Education, 39*(3).  Retrieved from http://scholar.lib.vt.edu/ejournals/JITE/v39n3/satchwell.html.

Siegler, R.S. (1986). Piaget's theory of development. in *Children's Thinking* (pp. 21-61). Englewood Cliffs, NJ: Prentice Hall.

Sivin-Kachala, J. (1998). *Report on the effectiveness of technology in schools, 1990-1997*. Washington, DC: Software Publishers Association.

Sklar, E., Eguchi, A., & Johnson, J. (2002). Children's learning from team robotics: RoboCupJunior 2001. *Proceedings of RoboCup-2002: Robot Soccer World Cup VI.*

Sklar, E., Eguchi, A., & Johnson, J. (2003). Scientific Challenge Award: RoboCupJunior - Learning with Educational Robotics. *AI Magazine, 24*(2), 43-46.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*, 613–629.

STEM NS, (n.d.). Growing a better tomorrow with STEM. Retrieved from

    http://www.stemns.com/index.html

Striegel, A., & Rover, D. (2002). Problem-based learning in an introductory computer

    engineering course. In D. Budny & G. Bjedov (Eds.), *Proceedings of the 31st*

    *ASEE/IEEE frontiers in education conference.* Piscataway, NJ: IEEE.

Vandebona, U., & Attard, M. M. (2002). A problem-based learning approach in a civil

    engineering curriculum. *World Transactions on Engineering and Technology*

    *Education, 1*(1), 99–102.

Vernado, T. E. (2005). *The effects of a technological problem solving activity on FIRST*

    *LEGO league participants' problem solving style and performance.* Doctoral

    dissertation, Virginia Polytechnic Institute and State University, Blacksburg.

Weinberg, J.B., & Yu, X. (2003). Robotics in education: Low cost platforms for teaching

    integrated systems. *IEEE Robotics & Automation Magazine*, *10*(2), 4–6.

Welch, A. (2010). Using the TOSRA to assess high school students' attitudes toward

    science after competing in  the FIRST Robotics Competition: An exploratory

    study. *Eurasia Journal of Mathematics, Science, & Technology Education, 6*(3),

    187-197.

Welch, A., & Huffman, D. (2011). The effect of robotics competition on high school

    students' attitudes toward.  *School Science and Mathematics, 111*(8), 416-424.

Werry, I., Dautenhahn, K., Ogden, B., & Harwin, W. (2001). Can social interaction skills

    be taught by a social agent? The role of a robotics mediator in autism therapy. In

    *Proceeding of the 4th International Conference on Cognitive Technology* (pp. 57–

    74).

Whitehead, S. H. (2010). *Relationship of robotic implementation on changes in middle school students' beliefs and interest toward science, technology, engineering and mathematics.* Indiana University of Pennsylvania, Doctoral thesis. Retrieved from: http://dspace.iup.edu/bitstream/handle/2069/335/?sequence=1

Williams, D., Ma, Y., Prejean, L., & Ford, M. J. (2007). Acquisition of physics content knowledge and scientific inquiry skills in a robotics summer camp. *Journal of Research on Technology in Education*, 40, 201–216.

**APPENDIX A: INVITATION LETTER**

Dear Madam/Sir

Hello.

My name is Ahmad Khanlari, a Master of Education student at Memorial University of Newfoundland. Currently, I am working on my thesis research under the supervision of Dr. Mary Stordy.  My research focuses on **teachers' perceptions of using robotics on STEM education in primary/elementary schools in Newfoundland and Labrador**. I would like to invite you to participate in my study. You may choose to participate in an interview session or you may fill out an online survey.

If you are interested in participating in this study, please contact me at a.khanlari@mun.ca by **March 9th**, so I can arrange a time with you, based on your availability, for a short interview. If you are more interested in only doing an online survey, please kindly click here and fill out the online survey by **March 16th**.

The interview should last at the most 60 minutes, and the survey may take 30 minutes for completion. Furthermore, in order to provide you with useful information about robotics and its applications in education, a website has been created ( http://robotics-stemeducation.yolasite.com/ ). This website includes some short videos and an article about robotics and its educational applications. If you do not have any experience with (or any information about) using robotics in schools, you need to look at the project's website, watch some of the videos, and read the article before participating in the study (the website review may take 1 hour). However, it is not necessary to review the website if you already have some information about educational robotics.

Regardless of the method of participation, your answers will be kept completely confidential; you will not be asked to introduce yourself or give any information that would identify you or your school. The results of the survey/interview will be reported in a coded format, so no one will have access to your responses. Please be advised that your participation is completely voluntary and you may withdraw at any time during the interview/survey or even after attending in the interview/submitting the survey. However, if you withdraw after attending in the interview/submitting the survey, the gathered data will be retained safely with other data (in password-protected folders) for five years and then will be destroyed.

An informed consent form is attached to the email. It should give you the basic idea of what the research is about and what your participation will involve.  It also describes your right to withdraw from the study at any time.  In order to decide whether

you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. In the interview session, you will be provided with a hard copy of this form to sign. Please be advised that an informed consent is embedded in the online survey; therefore, you do not need to sign and send the consent form if you are going to complete the online survey.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

Furthermore, the proposal for this research has been reviewed and approved by the Newfoundland and Labrador English School District.

You can find more information about the study in the project's website. Please do not hesitate to contact me or my supervisor Dr. Stordy at mstordy@mun.ca if you have any questions.

I appreciate your time in considering this request, and I will be very thankful for your participation as I research this emerging educational area of robotics in primary/elementary schools.

Thank you,

Ahmad Khanlari

Masters' Student

Faculty of Education, Memorial University of Newfoundland

Webpage: https://sites.google.com/a/mun.ca/ahmad-khanlari/home

**APPENDIX B: INFORMED CONSENT FORM**

**Informed Consent Form**

Title:              Teachers' perceptions of using robotics in primary/elementary
                    schools in Newfoundland and Labrador

Researcher:         Ahmad Khanlari, Faculty of Education, Memorial University of
                    Newfoundland, a.khanlari@mun.ca, (709)763-6903

You are invited to take part in a research project entitled "Teachers perceptions of using robotics in primary/elementary schools in Newfoundland and Labrador."

This form is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study at any time. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is the informed consent process. Take time to read this carefully and to understand the information given to you. Please contact the researcher, Ahmad Khanlari, if you have any questions about the study or for more information not included here before you consent.

It is entirely up to you to decide whether to take part in this research. If you choose not to take part in this research or if you decide to withdraw from the research once it has started, there will be no negative consequences for you, now or in the future.

**Introduction**

My name is Ahmad Khanlari, a Master of Education student at Memorial University of Newfoundland. As part of my Master's thesis, I am conducting research under the supervision of Dr. Mary Stordy. My research focuses on teachers' perceptions of using robotics on STEM education in primary/elementary schools in Newfoundland and Labrador.

Along with robotics technology development, researchers and educators in many countries, including Canada, Japan, South Korea, Taiwan, and the United States have employed robots to support education. Robotics might be used as a learning object or as a learning tool. In the first category (learning object), robotics on its own is studied as a subject, while in the second category (learning tool) robotics is used as a tool for teaching and learning other school subjects such as mathematics and science.

Researchers have claimed that no age is too young to be engaged by robots and even four-year old children can construct simple robots and program them. However, little research has been conducted about robotics and its effectiveness in Science, Technology, Engineering, and Mathematics (STEM) education in primary/elementary schools. There is also limited research about teachers' perceptions of using robotics technology in Primary/Elementary schools. Thus, more exploration is needed to fill this gap in the existing literature. This study sets out to contribute to this gap in the research literature and to understand elementary school teachers' perceptions of using educational robots.

**Purpose of study:**

The primary focus of this research is to investigate teachers' perceptions of the use of robotics in primary/elementary classrooms.  We aim to understand whether primary/elementary teachers perceive robotics as a useful tool for teaching STEM-related subjects or not. If yes, in what capacity do they think robotics might be useful for STEM education?

The aim of teaching Science, Technology, Engineering and Mathematics (STEM) education is not only to help students to promote their knowledge in these disciplines, but is also to help students to become lifelong learners. For example, as outlined in the Newfoundland and Labrador Mathematics curriculum document, "[t]here are critical components that students must encounter in a mathematics program in order to achieve the goals of mathematics education and embrace lifelong learning in mathematics" (Department of education, 2009, p. 5). In fact, the mathematics outcomes are categorized into two different categories: Knowledge and Skills; students are expected to improve their skills as well as promote their knowledge. These components and skills include communication, connection, problem solving, reasoning, and visualization. Additional goals and objectives of the STEM education in Canada include developing positive attitudes in students about STEM fields, promoting student interests toward STEM disciplines, and encouraging students to pursue education and careers in STEM- related fields (STEM NS, n.d.; Canadian association of science centre, 2010). Therefore, in this study, we also will examine the effects of using robotics as an educational tool to promote students' interests toward STEM disciplines and encouraging them to study and work in STEM-related disciplines.  This study seeks to examine teachers' perceptions of the effects of using robotics as an educational tool on STEM education in primary/elementary schools.

**What you will do in this study:**

In this study, you will be asked to either participate in a face-to-face interview or fill out an online survey about using robotics in primary/elementary schools. In order to provide you with useful information about robotics and its applications in education, a website has been created ( http://robotics-stemeducation.yolasite.com/ ). This website includes some short videos and an article about robotics and its educational applications. You need to look at this website, watch the videos, and read the article if you do not have any experience with (or any information about) using robotics in schools. Then, you will be invited to take part in a short interview that will be held at the faculty of education, Memorial University of Newfoundland. You can also choose the online survey instead of an in-person interview. If you are more interested in only doing an online survey, please click here.

**Length of time:**

The expected time commitment is:
I.      Approx. 1 hour for the website review AND

II.     EITHER approx. 1 hour for an interview OR approx. 30 minutes for the online survey.

**Withdrawal from the study:**

Please be advised that your participation is completely voluntary and you may withdraw at any time during the interview/survey or even after attending in the interview/submitting the survey. However, if you withdraw after the interview/survey, the gathered data will be retained safely with other data (in password-protected folders) for five years and then will be destroyed. It is entirely up to you to decide whether to take part in this research.  If you choose not to take part in this research or if you decide to withdraw from the research once it has started, there will be no cost or negative consequences for you, now or in the future. So you can easily stop participating in the study at any time. Either you decide to continue to participate in the study or stop your involvement, the gathered data will be kept secured in password-protected folders for a minimum of five years, as per Memorial University policy on Integrity in Scholarly Research and then all the data (recorded interviews, transcribed data, completed surveys, etc.) will be destroyed.

**Possible benefits:**

By participating in this study, you will be introduced to robotics, which is considered a new way for teaching Science, Technology, Engineering and Mathematics (STEM) in 21st century. This study will help the scholarly community to figure out teachers' perceptions of using a new technology (robotics) for STEM education in primary/elementary grades. This study also helps the scholarly community to be aware of the support that teachers need for integrating robotics into primary/elementary schools for STEM education. Furthermore, robotics is almost unknown in primary/elementary grades in Newfoundland and Labrador; therefore, this study and its results would be beneficial for educators in Newfoundland and Labrador.

**Possible risks:**

There is no risk (e.g. physical risks, Psychological/emotional risks, financial, and social risks) of being in this study.

**Confidentiality and Storage of Data:**

A recording device will be used to record the interview for transcription to enable further analysis. The files will be stored in password-protected folders for a minimum of five years, as per Memorial University policy on Integrity in Scholarly Research and then all the interview files will be destroyed. Furthermore, the completed surveys and transcribed data will be safely stored in password-protected folders for five years. Only the main researcher and his supervisor will have access to the surveys, records, and transcribed data that are stored in password-protected folders.

If you are more interested in only doing an online survey, please be advised that the on-line survey company, Google, hosting this survey is located in the United States and as such is subject to U.S. laws.  The US Patriot Act allows authorities access to the records of internet service providers.  Therefore, confidentiality cannot be guaranteed.  If

you choose to participate in this survey, you understand that your responses to the survey questions will be stored and may be accessed in the USA.

**Anonymity:**
    Through the study (e.g. data gathering, data analysis, etc.) I will use pseudonyms in order to protect anonymity of the participants. Furthermore, you will not be asked to introduce yourself or give any information that would identify you or your school. For the information that would identify you or your school (e.g. the name of your school, your students, and the principal), pseudonyms will be used through the study. The results of the surveys/interviews will be reported in a coded format, so no one will have access to your responses.

**Recording of Data:**
    The researcher will use a recording device to record the interview session for transcription to enable further analysis. The audio files will be stored in password-protected folders for five years and then will be destroyed. However, if you do not want to be recorded, the audio-recorder will not be used, instead, your expressions will be written by the researcher.

**Reporting of Results:**
    The collected data will be coded, the main themes will be extracted, and the results will be reported in a thesis. To support the extracted themes, the researcher will use direct quotations where necessary.

**Sharing of Results with Participants:**
    After analyzing data, a summary of the research and the results of the analysis will be emailed to you so that you have a chance to know others' ideas of using robotics in primary/elementary grades.

**Questions:**
    You are welcome to ask questions at any time during your participation in this research.  If you would like more information about this study, please contact me (Ahmad Khanlari, a.khanlari@mun.ca) or my supervisor (Dr. Mary Stordy, mstordy@mun.ca ).

    The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy.  If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.
    Furthermore, the proposal for this research has been reviewed and approved by the Newfoundland and Labrador English School District.

**Consent:**
    Your signature on this form means that:
    • You have read the information about the research.

- You have been able to ask questions about this study.
- You are satisfied with the answers to all your questions.
- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw from the study at any time, without having to give a reason, and that doing so will not affect you now or in the future.
- You understand that any data collected from you up to the point of your withdrawal will be retained by the researcher for use in the research study.

If you sign this form, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

**Your signature:**
I have read what this study is about and understood the risks and benefits. I have had adequate time to think about this and had the opportunity to ask questions and my questions have been answered.

I agree to participate in the research project understanding the risks and contributions of my participation, that my participation is voluntary, and that I may end my participation at any time.
I agree to be audio-recorded during the interview
I do not agree to be audio-recorded during the interview
I agree to the use of quotations but do not want my name to be identified in any publications resulting from this study.

A copy of this Informed Consent Form has been given to me for my records.


_____                    _____

Signature of participant                                                     Date



**Researcher's Signature:**
I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.


_____                    _____

Signature of Principal Investigator                                      Date

**APPENDIX C:  ONLINE SURVEY**

# Teachers' Perceptions of using Robotics in Primary/Elementary Schools in Newfoundland and Labrador.

## SECTION 1. Your background and teaching style

**1. Gender (Voluntary declaration):**

[                    ]

**2. How many total years of teaching experience do you have, including this year?**

[                    ]

**3. Current teaching position:**

[ Primary Grades        ▼ ]

**4. Preferred teaching methodology (choose only one)**

[ Largely teacher-directed (e.g., teacher-led discussion, lecture)        ▼ ]

**5. How would you rate student access to technology at your school? (0-100 scale)**

[                    ]

**6. How would you rate teacher access to technology in your school? (0-100 scale)**

[                    ]

[ « Back ]  [ Continue » ]

Powered by Google Docs

Report Abuse - Terms of Service - Additional Terms

# Teachers' Perceptions of using Robotics in Primary/Elementary Schools in Newfoundland and Labrador.

## SECTION 2. Your experience with technologies

**7. Please indicate how often you integrate various technologies (e.g. computer technologies, smart boards, clickers, etc.) in your teaching activities.**

| Not at all ▾ |

**8. If you use technologies in your classes, what digital technologies do you use in an average term?**

[ text box ]

**9. What proportion of time on average do you use digital technologies in your lessons?**

| 0-20% ▾ |

**10. Please read the following descriptions of the proficiency levels a user has in relation to robotics technology. Determine the level that best describes you.**

| Unfamiliar: I have no experience with robotics technologies. ▾ |

[ « Back ]  [ Continue » ]

Powered by Google Docs

Report Abuse - Terms of Service - Additional Terms

# Teachers' Perceptions of using Robotics in Primary/Elementary Schools in Newfoundland and Labrador.

## SECTION 3. Your Process of Integration of Robotics

**11. Please indicate how frequently robotics technologies are integrated into your teaching activities.**

**12. If applicable, please indicate the total amount of Pre-service/In-service training you "have received" to use robotics technology in the classroom:**

Not Applicable ⌄

**13. If applicable, please indicate the total amount of Pre-service/In-service training you "need" to use robotics technology in the classroom:**

Not Applicable ⌄

**14. Please read the descriptions of each of the six stages related to the process of integrating robotics technology in teaching activities. Choose the stage that best describes where you are in the process.**

Awareness: I am aware that robotics exists, but have not used it – perhaps I'm even avoiding it. ⌄

**14.1. Please explain how you gained the above mentioned knowledge about robotics and its educational applications.**

**15. Do you think it would be useful to use robotics technology in primary/elementary schools?**

Not sure ⌄

Please explain why you think so:

16. The following statements may be considered as the potential obstacles that may prevent primary/elementary teachers from using robotics technology with their students. Please indicate whether any of the following would be obstacles for using robotics as an educational tool in primary/elementary schools.

| | Major obstacle | Small obstacle | Not an obstacle | I'm not sure |
|---|---|---|---|---|
| a) Usually there are not enough educational robots available in primary/elementary schools. | ○ | ○ | ○ | ○ |
| b) Usually teachers do not have access to adequate and relevant software/hardware in primary/elementary schools. | ○ | ○ | ○ | ○ |
| c) It is too difficult to schedule time in primary/elementary school's robotics projects to do the assignments. | ○ | ○ | ○ | ○ |
| d) There are not enough computers available in primary/elementary schools to program the robots | ○ | ○ | ○ | ○ |
| e) primary/elementary students are too young to be able to understand robotics and work with robots. | ○ | ○ | ○ | ○ |
| f) There is too much course material and many subjects to cover in a year to have time for robotics | ○ | ○ | ○ | ○ |
| g) Usually primary/elementary teachers are not sure how to make robotics technology relevant to their subject. | ○ | ○ | ○ | ○ |
| h)Teachers need to prepare students for the stated outcomes and mandated tests, while using robotics does not prepare them for these tests and outcomes | ○ | ○ | ○ | ○ |
| i) Usually primary/elementary teachers do not feel confident enough in their technology skills to use robotics in their classes | ○ | ○ | ○ | ○ |
| j) primary/elementary teachers do not have adequate administrative support | ○ | ○ | ○ | ○ |
| k) Teachers do not have adequate technical support. | ○ | ○ | ○ | ○ |
| l) Teachers do not have adequate instructional support | ○ | ○ | ○ | ○ |

**16.1. Please indicate any other obstacles that teachers may encounter and not listed above.**

**16.2. What kinds of support do teachers need to be able to employ robotics in primary/elementary schools?**

**17. The following statements are the potential benefits that may encourage primary/elementary teachers to use robotics technology in their classes. Please indicate the extent to which you agree or disagree with each statement.**

|  | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| a) Robotics has the potential to facilitate learning of mathematics in primary/elementary schools | O | O | O | O | O |
| b) Robotics has the potential to facilitate learning of science subjects in primary/elementary schools | O | O | O | O | O |
| c) Robotics has the potential to improve technology literacy in primary/elementary schools | O | O | O | O | O |
| d) Using robotics in primary/elementary schools can help students to become lifelong learners | O | O | O | O | O |
| e) Using robotics in primary/elementary schools can help students in the process of scientific inquiry, and improve their skills of initiating and planning, performing and recording, analysing and interpreting. | O | O | O | O | O |
| f) Using robotics in primary/elementary schools can develop positive attitude about STEM disciplines | O | O | O | O | O |

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| g) Using robotics in primary/elementary schools can encourage students to pursue their education and career in STEM-related fields | ○ | ○ | ○ | ○ | ○ |
| h) Using robotics in primary/elementary mathematics helps students to improve their mathematical reasoning and problem solving skills | ○ | ○ | ○ | ○ | ○ |
| i) Using robotics in primary/elementary science subjects helps students to improve their communication and team work skills. | ○ | ○ | ○ | ○ | ○ |
| j) Overall, students are actively involved in the lesson/unit than they are with comparable lessons/units that do not involve robotics technology. | ○ | ○ | ○ | ○ | ○ |
| k) Overall, students work together more than they do on comparable lessons/units that do not involve robotics technology | ○ | ○ | ○ | ○ | ○ |
| l) Overall, students' different learning styles are better accommodated than they are with comparable lessons/units that do not involve robotics technology. | ○ | ○ | ○ | ○ | ○ |
| m) Overall, student work showed more in-depth understanding of content than in comparable lessons/units that do not involve robotics technology. | ○ | ○ | ○ | ○ | ○ |
| n) Overall, student work is more creative than in comparable lessons/units that do not involve robotics technology. | ○ | ○ | ○ | ○ | ○ |

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| o) Overall, students are able to communicate their ideas and opinions with greater confidence than in comparable lessons/units that do not involve robotics technology. | ○ | ○ | ○ | ○ | ○ |
| p) Overall, students help one another more than they do on comparable lessons/units that do not involve technology. | ○ | ○ | ○ | ○ | ○ |

**17.1. Please give some examples, if there are any, of primary/elementary mathematics subjects which might be taught using robotics.**

**17.2. Please explain how robotics can help students to learn the mathematics subjects that you mentioned above.**

**17.3. Please give some examples, if there are any, of primary/elementary science subjects which might be taught using robotics.**

**17.4. Please explain how robotics can help students to learn the science subjects that you mentioned above.**

**17.5. Please give some examples, if there are any, of any other subjects in primary/elementary schools which might be taught using robotics.**

**17.6. Please explain how robotics can help students to learn the subjects that you mentioned in 17.5.**

**17.7. Please explain how robotics might develop positive attitude about STEM disciplines in primary/elementary students (if you think so).**

**17.8. Please explain how robotics might encourage primary/elementary students to pursue their education or career activities in STEM-related disciplines (if you think so).**

**17.9. Please explain how robotics in primary/elementary mathematics might help students to improve their mathematical reasoning and problem solving skills (if you think so).**

**17.10. Please explain how robotics in primary/elementary schools might help students to improve their communication and team work skills (if you think so).**

**17.11. Please explain how robotics in primary/elementary schools might improve students' skills of initiating and planning, performing and recording, analysing and interpreting (if you think so).**

**18. Suppose your school administration annually made additional resources available (example: release time) for improving robotics based instruction. In your opinion, what kinds of resources should they provide? How would you like to see these resources used in order to improve your instructional use of robotics?**

« Back    Continue »

Powered by Google Docs

Report Abuse - Terms of Service - Additional Terms

# Teachers' Perceptions of using Robotics in Primary/Elementary Schools in Newfoundland and Labrador.

## Section 4. Please choose the ideal use, if any, of robotics technology in the classroom.

### 19. You perceive that the use of robotics technology in the classroom…
(You can choose as many as options that you want)

☐ Increases academic achievement (e.g. grades).

☐ Increases student proficiency in collaboration

☐ Increases student proficiency in data analysis.

☐ Increases student proficiency in presenting to an audience.

☐ Increases student proficiency in research.

☐ Prepares students for future jobs.

☐ Supports student remediation in basic skills such as math and reading.

☐ Enables students to express their ideas and opinions.

☐ Improves student test scores.

☐ Promotes active learning strategies.

☐ Satisfies parents and community interests.

☐ Improves your own productivity and efficiency.

☐ Results in students neglecting important traditional learning resources (e.g., library books).

☐ Is effective because I believe I can implement it successfully.

☐ Promotes student collaboration.

☐ Makes classroom management more difficult.

☐ Promotes the development of communication skills (e.g., sharing ideas and presentation skills).

☐ Is a valuable instructional tool

☐ Is too costly in terms of resources, time and effort.

☐ Is successful only if teachers have access to robotics technology.

☐ Makes teachers feel more competent as educators.

☐ Is successful only if there is adequate teacher training in the use of robotics technology for learning.

☐ Gives teachers the opportunity to be learning facilitators instead of information providers.

☐ Demands that too much time be spent on technical problems.

☐ Is successful only if there is the support of parents.

☐ Is an effective tool for students of all abilities.

☐ Enhances my professional development.

☐ Eases the pressure on me as a teacher.

☐ Motivates students to get more involved in learning activities.

☐ Increase students interest towards Science, Technology, Engineering, and Mathematics (STEM) disciplines.

☐ Limits my choices of instructional materials.

☐ Requires Hardware/Software-skills training that is too time consuming.

☐ Promotes the development of students' interpersonal skills (e.g., ability to relate or work with others).

☐ Will increase the amount of stress and anxiety students experience.

☐ Is difficult because some students know more about robotics than many teachers do.

☐ Is only successful if robotics technology is part of the students' home environment.

☐ Requires extra time to plan learning activities.

☐ Improves student learning of critical concepts and ideas.

☐ Becomes more important to me if the student does not have access to a robot at home.

☐ Increases my workload in the short term

☐ Increases my workload in the long term

**Your overall opinion about using robotics for teaching STEM-related subjects in primary/elementary schools.**

| |
|---|

| « Back | Submit |
|---|---|

Never submit passwords through Google Forms.

Powered by Google Docs