

# Long Term Effects of Educational Robots on a Grade 9 Girl's Perceptions of Science and Math

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**Abstract-** A review of literature highlighted a few important aspects of using robotics for educational purposes. However, most of the studies did not examine the long term effects of educational robots, but only considered a short period of time, when their participants were involved in robotics courses. Also, in most of the studies, the gender differences are not considered and the effects of robotics on girls are overlooked. This case study examines the effects of educational robots on Sarah, a grade 9 student who has attended in a robotics summer camp when she finished her Grade 8. The participants of this study include Sarah and her mother, who is a science teacher. This case study examines the long term effects of educational robots on Sarah, almost one year after she finished her summer camp robotics course. Based on the preliminary results of this study, the long term effects of robotics on Sarah include motivating her to learn mathematics, science, and technology. The results also show that using robotics in the education system would result in fewer gender-based stereotypes, regarding technical majors and careers. This study shows that robotics also could create an environment where Sarah, as a girl, were immersed in authentic education, and helped her improve her critical thinking and problem solving skills.

*Index Terms* – Girls' perceptions, Robotics, science education, math education.

## INTRODUCTION

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 [1]. For example, the results of the pretest and posttest of a study about effects of a driver gear on the follower gear [2] showed that robotics intervention improves students' perceptions of relative speed (faster, slower, or same speed) of the follower gear. The results of this study also indicated that using robots increases correct answers about the large-large, medium-small, and medium-small-medium combination of gears and helps students to improve their ideas about the relation between the number of gears and the relative speed of the follower gears. 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" [3]. 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). Also, robotics has the potential to attract students toward Science, Technology, Engineering, and Mathematics (STEM) disciplines and leads them to "fall in love with these subjects and all that science, technology, engineering, and mathematics make possible in our world" [4].

However, while robotics intervention, like any other intervention, may have long-term and short-term effects on students, most of the studies have examined robotics in a short period of time and did not examine the long-term effects of robotics. In fact, most of the studies are done while robotics is being taught and students are involved in robotics activities, not after the robotics course is done. Moreover, almost all the studies employed pre-tests and post-tests to examine the effects of robotics, and they did not carefully examine the effects of robotics from students' points of view. This study aims to fill these gaps in the existing literature, give voice to students, and figure out their perceptions and experiences of the effects of educational robots on students. This study also aims to involve parents, because parents are the best people to evaluate their kids outside of the education system. This study, particularly, is focusing on girls experiences, as "girls usually feel inferior" regarding technical subjects [5]. Therefore, the purpose of this case study is to examine the potential effects of robotics on girls' perceptions about science and math. The main research question that will be addressed in this study is:

What are the potential long-term effects of educational robotics on a girl's academic journey, from the perspective of herself and her mother?

This study employs a qualitative case study method to address the above-mentioned research question.

## THEORETICAL FRAMEWORK

This study grounded in Constructionism that draws on constructivism and stresses a hands-on aspect [6] Constructionism emphasizes that building a tangible and meaningful object, finding problems, and solving them is the most efficient way to learn. 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" [6]. Papert argued that using the Lego NXT in the classroom allows for a constructionist approach to benefit instruction and student learning. The author of [7] found that robotics supports Constructionism theory by developing meaningful learning and understanding through hands-on and cooperative activities.

## METHODOLOGY

In this study, a qualitative research technique derived from case study methodology has been employed in order to gather and evaluate data. A case study is defined as “an intensive, holistic description and analysis of a single instance, phenomenon, or social unit” [8] in which the researcher “investigates a contemporary phenomenon within its real-life context” [9], using “detailed, in-depth data collection” [10]. Case studies are valuable for creating deep and comprehensive understanding of particular people, problems or situations [11] and provides rich information about the topic [12]. Merriam [13] states that “[a] case study design is employed to gain an in-depth understanding of the situation and meaning for those involved” (p. 19). In a case study, “[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)” [14]. 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 [10]. This study is particularly suitable for a case study design, because the impact of educational robotics on girls’ perceptions about science and math is not well understood and this study aims to gain an in-depth understanding of females’ perceptions and experiences of using educational robotics in a real life context.

## PARTICIPANTS AND PRELIMINARY RESULTS

The participants of this study included Sarah, who is now at the end of her Grade 9 and had attended in a robotics summer camp in the past summer, and her mother, who is a science teacher. Sarah’s junior high school academic records show that although she was generally a good student in Grades 7 and 8, her math and science marks were not as good as her other marks. Both Sarah and her mother believed that the lack of motivation was the main reason for Sarah’s low grades in math and science. During our conversation, Sarah, who has finished a robotics course in the last summer, stated that her math and science marks are improved after she became familiar with robotics. She explained the robotics summer camp was a 6-weeks camp which basically provided basic information about robotics, its importance in 21<sup>st</sup> century industry, kind of expertise required to build a robot (i.e. electrical engineering, mechanical engineering, and programming), and their prerequisite knowledge (e.g. mathematics, science). During the summer camp students also were engaged in hands on activities to build robots to do different tasks, including (but not limited to) drawing simple shapes, moving up a hill while carrying a ball, and playing soccer (based on their own choices). Students not only were asked to do hands on activities, but also were asked to explain how their projects are related to the science and math units they have learned at school. They were also asked to search how different part of their robot work and provide scientific explanations. For example, they were asked to explain what causes motors to move, and how a gearbox works. Overall, the summer camp’s

main goal was to provide an opportunity for students to deeply think about robotics and its different parts (e.g. actuators, sensors, CPU) as opposed to many other robotics courses which just ask students to do hands-on activities with little consciousness about behind the scenes of robots’ actions. The final evaluation criteria included innovations, making connections between the project and the science and math units learned at school, and the robot’s efficiency.

Sarah claimed that robotics not only helped her to learn some difficult science topics such as electricity, but also helped her to realize that science-related subjects, such as levers and gears, are applicable in the real world, and motivated her to study hard. She continued that she thinks math problems involving measuring, estimating and counting can easily be taught using robotics. When I asked her to explain why her grades are improved, she stated that the main reason is motivation and interest. She claimed that before taking robotics, she was not motivated to learn math and science, because some math and science units did not make sense to her and she used to think math and science are useless. However, after being involved in some robotics activities, she realized that math and science are important subjects and are applicable in real world. Therefore, she is now more motivated and interested in learning these subjects.

Moreover, Sarah talked about her desire to choose a major related to robotics in university level. I intentionally told her that robotics is a branch of the engineering field, and asked her whether she was thinking to pursue her study in the field of engineering. She responded:

*I was not interested in studying in engineering or math-related fields, because I didn't like these subjects at all. I used to think that these fields are not suitable for girls and girls cannot succeed in technical fields, because all the famous people in these areas, such as Steve Jobs and Mark Zuckerberg, are male.*

However, after successfully finishing her summer camp robotics course, she believes girls can succeed in engineering and technical subjects. When I asked her why she now thinks girls can succeed in technical subjects, she talked about her experience in the past summer:

*Jennifer [her robotics teammate] and I built a robot that was selected by the teacher as one of the top 3 robots in the class. This [achievement] made me believe that girls can build robots even better than boys, and I now love robotics.*

She now believes that robotics changed her mind about technical subjects and helped her to love engineering fields and math, and she is interested in studying robotics in her post-secondary education.

Sarah’s mother started the conversation by saying the following statement:

*Before taking this robotics course, Sarah always complained about math and was not interested in mathematics at all. After taking that course, I was surprised to see how she was doing her math assignments with interest. She [Sarah] believed if she learns mathematics well, she would be able to employ her math knowledge to build a perfect robot in the future.*

When she realized how robotics had motivated Sarah to learn math and Sarah's math marks are improved, she bought an educational robot kit for Sarah and both of them tried to learn working with that robot. Sarah's mother stated that Sarah always asks her to help her integrate robotics into different math and science units. Sarah's mother stated that both of them believe that robotics facilitates learning of science and math by providing hands on activities and visual feedback. Sarah's mother also stated that robotics not only motivated Sarah to learn mathematics and science, but also encouraged her to teach math to her Grade 2 sister and show her the relationships between programming, mathematics, and the robot's movement. Sarah's mother stated that Sarah uses her robot to teach mathematics topics such as geometry, numbers, and distances to her sister. Sarah's mother also continued that robotics is fun and has the potential to convince students that schools and courses can be fun too. For example, "sometimes Sarah tries to write a program to ask her robot to dance", Sarah's mother said. This kind of activities helped Sarah to become confident in her ability to use technology; the hands on feature of robotics led Sarah to believe she can manipulate the technology, as opposed to being controlled by technology. Sarah's mother also believes that the positive effects of robotics on Sarah was not limited to the above mentioned benefits. Robotics helped Sarah to become a self-confident student who tries to solve the problems by herself. Sarah's mother believes that robotics projects are meaningful challenges that can help students to improve their critical thinking and problem solving skills. As Sarah's mother stated, Sarah also has learned that real life is more complex than how it is perceived by students; she now knows that real life is composed of a series of successes and failures that students should gain experience from the failures in order to achieve successes.

## DISCUSSION AND CONCLUSION

The results of this case study indicates that robotics could motivate Sarah to learn difficult and technical subjects, such as math and science. Both the participants (Sarah and her mother) expressed that robotics has had an extreme influence on Sarah so not only does she love robotics, but also she likes to pursue her education in related fields. The participants' statements concur with the existing literature (e.g. [15], [16], [17] that robotics can facilitate learning of subject matter. However, both the participants believe that the main reason of the improvement in Sarah's math and science marks is that Sarah is now motivated to study and learn math and science. Also, the results of this study support the existing literature that

robotics has the potential to create an environment where students love STEM subjects and can persuade students to pursue their education and career in STEM-related fields [4], [18], [19], [20]. In fact, the results of this study concur with [21] that "students at all levels have become excited about engineering and have become interested in learning math and physics through creating with the [robotics] bricks", and robotics can make learning enjoyable and can motivate students to learn the material.

## FUTURE PLAN

Although this study is a pilot case study and 2 participants might be enough for a work in progress case study, the data is not enough to make a general conclusion about all girls. Therefore, for the future I am planning replicate the study with 20 more participants; 10 girls who attended in that robotics summer camp, as well as their parents, in order to be able to generalize the results.

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