

# EFFECTS OF ROBOTICS ON 21st CENTURY SKILLS

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## Abstract

Research indicates that robotics influences many educational aspects and has a great impact on students' abilities and skills. The present study seeks to examine teachers' perceptions of the effects of robotics on students' personal skills and the analysis reveals four major themes in this regard. A comparison between these themes and the 21st century learning framework shows that robotics is an effective tool for improving 21st century skills, including students' creativity, collaboration and team-working, self-direction, communication skills, social and cross-cultural skills, and social responsibilities. Therefore, robotics can be used as an effective tool to prepare students for the 21st century.

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**Keywords:** Robotics, 21st century skills, Self-confidence, Team-working, Sociality, Creativity

## Introduction

Researchers and educators have demonstrated that digital technology dramatically affects and changes students' personalities and identities, increases intellectual capacities, and participates "in the transformation of minds, that is experiences of consciousness" (Davis, B et al 2008). Technologies also encourage students' team-work and collaboration, and "have enabled more democratic, collective, and participatory" spaces (Davis et al., 2008). Robotics, as a new technology, has attracted educators' attention and has begun to be used as an educational tool. Therefore, there is a need to deeply examine the effects of robotics on students' personal skills and abilities. Some studies demonstrates that the use of robotics, as a new technology, can improve students' personal skills, such as self-confidence, problem solving, communication, acquire and evaluate information, creativity, decision making, and team work (Khanlari, 2013, Hussain et al., 2006; Nugent et al., 2010; Arlegui et al., 2008; Demetriou, 2011). Demetriou (2011) stated that mobile robotics has a great effect on team working ability and students' self-confidence. Hussain et al. (2006) in their

research project, “Programmable Construction Material in the Teaching Situation”, examined the pedagogical effects caused by the application of LEGO Dacta materials. The result of their study demonstrates that LEGO robotics enhances students’ team-working skills. Furthermore, the results of another quasi-experimental study that examined the impacts of robotics and geospatial technologies interventions on middle-school students show that robotics leads to greater self-efficacy and confidence for youth’s ability to perform robotics tasks (Nugent et al., 2010). Moreover, the authors of another study concluded that robotics activity promotes the creative attitudes of the students and their team-working and cooperation abilities (Arlegui et al., 2008).

These results are supported by educational theories such as Learning by Design theory. Learning by Design emphasizes that students learn as a result of collaboratively engaging in design activities and reflecting appropriately on their experiences (Kolodner et al., 1998). Learning by Design has been shown to enhance problem-solving, decision making, and collaboration skills (Nagel et al., 1999; Puntambekar et al., 1998).

According to the 21st century framework, in order to be prepared for complex lives and work environments, the 21st century students must learn essential skill set that helps them to become “engaged thinkers and ethical citizens with an entrepreneurial spirit” (Literacy, 2012; Alberta education, 2012). These skills, as shown in Fig. 1, are: creativity and innovation, critical thinking and problem solving, social responsibility and cultural, global and environmental awareness, communication, digital literacy, collaboration and leadership, lifelong learning and self direction and personal management (Literacy, 2012; Alberta education, 2012).

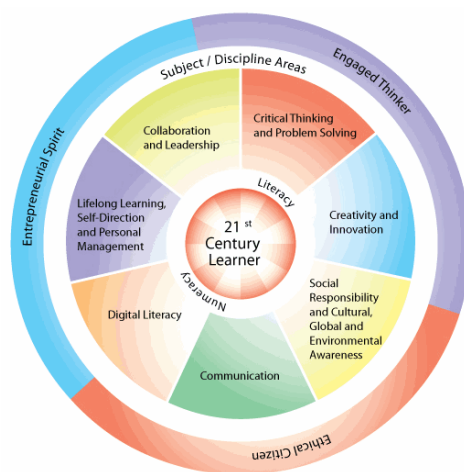


Figure 1. The 21<sup>st</sup> century skills (Alberta education, 2012)

However, the 21st century skill set is difficult to teach directly, because the skills are not based on particular subjects, but are related to the capacity of innovation (Orpwood et al., 2012).

The purpose of this study is to examine the impacts of using robots and robotics on students' skills and abilities. This study is designed to address the following question:

What are the teachers' perceptions of the effects of robotics on students' personal skills and abilities?

In order to address this question, a qualitative study was designed and data were gathered through a focus group and an interview. After analyzing data, the emerging themes were compared with the 21st century learning framework to determine the effects of robotics on the 21st century skills.

### **Design of the study**

A qualitative approach is used to achieve a deep understanding of the participants' experiences and perspectives of the effects of robotics on 21st century learners' skills and abilities. Data are collected through a focus group that was attended by six robotics teachers who have at least two years experiences teaching robotics. Also, another teacher who could not participate in the focus group was interviewed in another session. In order to enhance the credibility of the findings, all the statements were recorded. Additionally, precise descriptions and member checks were utilized.

### **Method**

#### *A. Participants*

The participants included seven teachers with two to seven years experience teaching robotics in schools, using simple robot kits that included some bricks, nuts and bolts, electrical circuits, and sensors. Two of the participants were females and the rest were males. All seven robotics teachers were electrical engineers and had some experience teaching mathematics, physics, or science at different grade levels. Excluding one of the participants who has only taught robotics in junior high school, all of the participants have taught at different grades and different levels.

Since all the participants were engineers and robotics teachers with an interest in teaching robotics, there was a danger that they would influence the results of the study by advocating the positive impacts of robotics on education. However, the participants were asked to make an effort to set aside any prejudgments. During the conversations, I realized that they were doing their best effort to set aside prejudgments. All the research participants voluntarily signed and returned the informed consents.

#### *B. Data Collection Procedures*

After receiving each informed consent, data collection occurred through a focus group over four hours and an interview over 30 minutes. During the session, the participants were asked to talk about their

experiences regarding teaching robotics. All the participants were free to express their thoughts and experiences. The participants were free to critique or complete other participants' expressions. Moreover, during the session and analysis, participants were kept anonymous.

### *C. Data Analysis*

The participants' statements were transcribed, I read the transcripts line-by-line, broke down the data to small sets of categories, and coded them based on their properties. Atlas-ti7, a code-based theory builder software, was used to code and analyze the data. Atlas-ti7 allows users to highlight pieces of texts and code them with specific names, based on the extent of a particular function. All transcripts were used to categorize the data based on the similar ideas or repeated word properties. The main categories and subcategories were identified and linked together, the links were supported with quotes and memos, and finally the themes were outlined. The emerging themes were compared with the 21st century learning framework, in order to determine the effects of robotics on the 21st century skills.

## **Results**

Research question of this study was:

What are the teachers' perceptions of the effects of robotics on students' personal skills and abilities?

The analysis revealed four major themes which address the research question. These themes are:

- Improving students' creativity.
- Improving students' team-working and collaboration skills.
- Improving students' self-confidence and independence.
- Improving students' sociality ability.

### *A. Improving students' creativity*

All participants indicated that robotics promotes students' creativity. For example, one of the participants stated:

*There are two types of creativity; in the first type, students innovate new things that did not exist previously, while in the second one, students recreate the existing things, using an innovative method. Robotics promotes students' creativity in both types of the creativity.*

Another participant continued this expression:

*In robotics classes, students do not learn only robotics, they learn to think creatively and critically; in the first session of the class, most of the students have no ideas about the robotics, but after three or four sessions, they express surprising creative ideas. Students also implement their creative ideas and build their robots.*

Another participant completed this expression, telling her experience:

*In one of my robotics classes, one of the students innovated a new model of automated dragline machines that was very efficient. The*

*government decided to support him financially to enhance his model, in order to be used in industrial applications.*

According to the 21<sup>st</sup> century learning framework, *creativity* is an essential skill that students must learn in order to be successful; education systems should prepare students to “create new and worthwhile ideas” (Literacy, 2012). Students should be able to employ a variety of techniques to create new ideas; analyze, evaluate, and refine their ideas; and improve their creative efforts (Literacy, 2012). Therefore, robotics can be considered a useful tool for preparing students for the 21<sup>st</sup> century, because it encourages students’ creativity.

However, one of the participants believed that there is a risk in robotics classes:

*If teachers advise students step by step and tell them what to do and how build their robots, students’ creativity will not be improved, and students just perform their teachers’ ideas.*

Therefore, teachers should be aware that their acts can encourage or discourage students’ creativity and critical thinking.

#### *B. Improving students’ team-working and collaboration skills*

Most of the participants (four participants out of seven) believed that the fear of working alone leads *elementary* students to start working together as a team and build their robot collaboratively. However, three other participants believed that elementary students enjoy working collaboratively, so they like to work as team and build their robots collaboratively. These three participants believed that one of the properties that distinguishes robotics from other courses is the team-work and collaboration; as students are free , and even encouraged, to work in a team, in contrast to the other courses where students have to work individually, they love robotics. Nevertheless, all the seven participants agreed that in *high school* and *junior high school*, students like to work in a team, in order to enhance their projects and build more efficient robots.

However, all seven participants expressed that robotics improves students’ ability to work collaboratively in a team, regardless of their grades:

*Robotics is a useful tool for students, specially for bashful students; it leads students to participate in team-projects. Indeed, in robotics classes, students learn to work as a team member.*

They also believed that:

*Robotics encourages students to work in a team, because students are aware that they can build a better robot when they collaborate in the project.*

Also, five participants stated that they had experiences when students’ parents thanked them, because their children are now more interested to work collaboratively as a team member.

According to the 21<sup>st</sup> century learning framework, contemporary education systems should also focus on collaboration and team-working skills, in order to prepare students effectively for complex living and working environments. As outlined in this framework, students should “assume shared responsibility for collaborative work” and be interested and be able to work effectively and respectfully in a group; they should develop and share their new ideas with others and perform their responsibilities effectively (Literacy, 2012). They also should listen effectively to others’ ideas; they should learn to be flexible and –when necessary- adapt themselves to other team members in order to reach the team goals (Literacy, 2012). Therefore, robotics is a useful tool for 21<sup>st</sup> century learners, because it improves *team-working* and *collaboration* skills.

Additionally, participants expressed that robotics “helps weak students to promote their skills and knowledge because they work with more knowledgeable students instead of leaving the task.” However, the participants expressed a risk in team-work projects:

*Sometimes the knowledgeable members of teams do most part of the project, and the weak members just do small tasks or even do nothing.*

Participants also stated that teachers have an important role in encouraging students’ team-working and collaboration skills; teachers should be well prepared to encourage students’ team-working ability. The participants claimed that this issue should be strongly considered in teacher education programs.

### *C. Improving students’ self-confidence and independence*

Participants believed that robotics encourages students’ self-confidence. One of the participants stated that:

*The hands-on robotics causes students practically learn the subjects, so they can remember the taught subjects for a long time. Later, they can use their knowledge in their lives and this promotes their self-confidence, because they see themselves as knowledgeable persons.*

Furthermore, some of the participants stated that, as robotics is a modern technology, the students who know robotics are more self-confident, because they know a new technology that many of their peers do not. Also, some other participants stated that students who have attended in robotics classes are more self-confident because robotics helps them to gain skills using tools such as nuts and bolts, screwdriver, and pliers; they learn to use soldering iron and utilize electrical circuits; they also learn to utilize programming software.

As it has been mentioned in the 21<sup>st</sup> century learning framework, it is not enough that students just learn basic skills and curriculum, but they should explore opportunities to expand their learning and gain expertise (Literacy, 2012). In the robotics classes, students not only learn robotics, but

also gain advanced skills and expertise that might be used in their lives. Therefore, robotics is a useful tool for the 21<sup>st</sup> century education system.

One of the participants claimed that this self-confidence leads students to be more independent from their parents and be more self-reliant. All the participants acknowledge his expression and one of them expressed her experience in this regard:

*One of my students in a summer camp did not stay in the class without his mom (even in the school, his mom attended with him in the class and she asked questions on behalf of her son!). His mom attended in the first three sessions of my robotics class, but when the theoretical parts finished and I started the practical parts, I asked his mom to leave the class. He was very interested to build his own robot, so he started his tasks alone, in order to build his own robot. Whenever he had a difficulty in building his robot, he quickly asked me his questions, in order to be able to make his robot quickly. After a few sessions, he became a self-reliant student who preferred to do his tasks alone; he did not like to ask help from his mom -and even from me-anymore. He even participated in a robotics competition, without asking help from his mom.*

This emerging theme also shows that robotics has a positive impact on another 21<sup>st</sup> century skills that is *self-direction*; the 21<sup>st</sup> century learning framework states that students should be self-directed learners; they should “[m]onitor, define, prioritize and complete tasks without direct oversight” (Literacy, 2012).

#### *D. Improving students’ sociality*

All the participants believed that robotics encourages students’ sociality. The participants claimed that although in regular courses students are encouraged to do their tasks alone, teachers encourage students to make connections with each other in robotics classes. This connection leads students to be more social. For example, one of the participants claimed that:

*In robotics classes, students make connections with each other, they ask their questions from their teammates and even from their friends in other teams or even other robotics classes, they use others’ knowledge and share their ideas with each other.*

Another participant stated her experience in this regard:

*I had a summer camp class that students from different grades were attending in. In this class, students in lower grades made connections with students in higher grades, to promote their knowledge and to build a more efficient robot. I can remember that in the last session, some of the parents thanked me and mentioned that their children did not use to communicate with others, but now they easily make connection with others, even with students who are greater than them.*

As outlined in the 21<sup>st</sup> century learning framework, students should have the ability to communicate with others for a variety of purposes, such as informing, instructing and motivating (Literacy, 2012). They should be able to develop and articulate their thoughts and new ideas to others; they also should learn to listen carefully to others ideas in order to figure out their attitudes, intentions, and thoughts (Literacy, 2012). This theme indicates that robotics influences students' *communication* skill that is another required skill for the 21<sup>st</sup> century.

One participant stated that students who learned robotics can participate in robotics competitions, so they make connections with their peers from other cities and countries and they can share their ideas with others. In his point of view, this is another example that shows robotics can promote students sociality.

The 21<sup>st</sup> century framework demonstrates that students should be able to effectively communicate in different environments, even in multi-lingual environments (Literacy, 2012). They also should respectfully and effectively communicate and work with people from different social and cultural backgrounds and “create new ideas and increase both innovation and quality of work” (Literacy, 2012). This theme shows that robotics can improve *social and cross-cultural* skills that are required for the 21<sup>st</sup> century learners (Institute of museum and library services, n.d.).

Participants also stated that robotics leads students to like their peers and help them to build their robots. One of the participants stated that:

*Initially students did not help their peers, but I asked some of the students who had finished their tasks to help other students who needed assistance. After a few sessions, students themselves were interested to help others.*

Other participants agreed with this expression, and acknowledge that robotics promote students' tendency to help others.

According to the 21<sup>st</sup> century learning framework, one of the skills that students should learn for the current century is the *social responsibility* (Alberta education, 2012; CAIS21stcentury, 2013) (CAIS21stcentury, 2013); students should Act “responsibly with the interests of the larger community in mind”, they also should demonstrate “ethical behavior in personal, workplace, and community contexts” (CAIS21stcentury, 2013). Also, as mentioned before, students should be able to *communicate* with others for instructing, informing, and motivating, they should also express their ideas to others and exercise willingness to help others (Literacy, 2012). Indeed, this theme shows that robotics is an effective tool in order to improve students' *social responsibility* and also their *communication*.

However, participants claimed that students just helped other students whom are not their rivals in robotics completions. The participants also



claimed that teachers have vital roles to change students' minds and encourage them to help their friends, without considering robotics competitions.

### **Discussion**

This paper examined teachers' perceptions of the effects of robotics on students' personal skills and abilities. The results of this study are consistent with the Learning by Design theory and shows that robotics enhances students' skills and abilities. The analysis revealed four different themes:

- Improving students' creativity and critical thinking.
- Improving students' team-working and collaboration skills.
- Improving students' self-confidence and independence.
- Improving students' sociality.

All the participants acknowledge that robotics improves students' creativity and critical thinking. However, the participants believe that teachers have a significant role in encouraging students' creativity and they should be aware that their acts can encourage or discourage students' creativity and critical thinking.

Similarly, although the participants believe that robotics encourages students' team-working and collaboration ability and also students' tendency to help others, they believe that teachers have a vital role in this regard and they can encourage or discourage this ability and tendency. Furthermore, all the participants agree that robotics improves students' self-confidence and sociality.

A comparison between the emerging themes and the 21<sup>st</sup> century learning framework shows that robotics can be used as an effective tool to improve the 21<sup>st</sup> century skills, including students' creativity, collaboration and team-working, self-direction, communication skills, social and cross-cultural skills, and social responsibilities. The 21<sup>st</sup> century workplaces highly require that students be equipped with these essential skills and robotics can be consider as a good tool that can help students to become prepared and equipped workforces.

### **Conclusion**

As it has been mentioned above, a literature review shows that robotics has great impact on students' characteristics and skills; it improve students' skills and abilities such as problem solving, critical thinking, decision making, team-working, self-confidence. The results of this study prove other study's results and show that robotics improves some of the students' skills, such as creativity and critical thinking, team working and collaboration skills, self-confidence, sociality, and tendency to help others. The results of the study also reveal that robotics has a great impact on the 21<sup>st</sup> century skills.

## **Future research**

In this study, I did not focus on a specific grade, because the participants had taught robotics in different grades. Therefore, there is a need for further research to examine the effects of robotics on different grades, focusing on a specific grade (elementary, junior high schools, and high schools). Furthermore, as the participants claimed that teachers have a crucial role that can mitigate or increase the effects of robotics on students' creativity, team-working skills, and tendency to help others, there is a need for further research to examine how robotics teachers can increase or decrease the effects of robotics on students' personalities.

## **Acknowledgement**

I would like to thank the managers of NADco (Noavaran Abzar Daneshamooz) company for hosting this research and providing me the opportunity to interview their robotic teachers. I also show my gratitude to the teachers who participated in this study.

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