Science Education International
31(1), 92-103
https://doi.org/10.33828/sei.v31.i1.10

International Council of Association for Science Education

ORIGINAL ARTICLE

More than Playing a Toy: The Effects of Lego Mindstorms on the Students' Perceptions about Scientists

Bülent Çavaş[1]*, L. Özge Güney[1], Emre Karagöz[1], Pınar Çavaş[2]

[1]Distance Education Application and Research Center, Dokuz Eylul University, Izmir, Turkey, [2]Department of Elementary Education, Faculty of Education, Ege University, Izmir, Turkey

***Corresponding Author:** bulentcavas@gmail.com

ABSTRACT

Lego has been a popular toy since 1932. "LEGO" is an abbreviation of two Danish words "leg godt" which means "play well." In today's LEGO-based learning and teaching environments, it has been revealed in studies that students working to solve problems presented to them were often unaware of how much time has passed. In this study, it was aimed to determine how Lego Mindstorms EV3 based robotics education changed the concept of what is a scientist in the minds of students. Twenty-one students from the 5th, 6th, and 7th grades participated. In the study, a single group pre-test and post-test design was applied. The "Draw a scientist test (DAST)" measurement tool was used to reveal the perceptions of scientists. In the study, a program developed for robotic education was offered to students during the robotic club hours for 4 weeks. DAST was administered to the students before and after the robotic education. The students worked in groups and participated in structured, guided, and inquiry-based learning. In the past week, students were asked to develop solutions to a socio-scientific problem using the Lego Mindstorms kit. The findings showed that the students changed their drawings using different styles in not only the scientists' body and facial expressions but also work environments. The results show that Lego Mindstorms EV3 based robotics education played an important role in changing the perceptions of scientists in the students' minds.

KEY WORDS: Lego Mindstorms EV3; robotics education; scientist; perception; inquiry

INTRODUCTION

It has been reported that there is a dramatic decrease in students' attitudes and interest in science and technology as a result of progressing up through the grade levels (Hofstein et al., 1990; Ornstein, 2006; Osborne et al., 2003; Sadi and Cakiroglu, 2011). One reason for this decrease is that activities in science classes are often teacher centered. Another serious problem in the field of science education is that the students' perceptions of scientists are based on stereotypes (Bernard and Dudek-Różycki, 2017; Lavonen et al., 2008). It is not right to expect a positive perception of a scientist in a student's mind when they have low motivation and interest in science and technology courses. This situation has been addressed in European countries as well as in many other countries and it has been decided to make important investments in science and technology education. For example, the issue of lack of student motivation has been a central topic of many European Commission funded projects (such as PARSEL, 2009; POLLEN, 2009; PROFILES, 2014) investigating innovative and meaningful ways and methods to get students' attention in science and to increase their motivation and attitudes toward science and technology courses. The primary aim of these projects is to make innovative changes in the traditional science curriculum process and to create innovative educational modules to attract young students' motivation and interest toward the fields of science and engineering. Lego Mindstorms is one such effective tool to change students' motivation and interest toward positive. Lego Mindstorms is used effectively in many teaching and learning environment of those projects implemented not only to develop students' academic achievement but also improve their motivation and interest toward science and technology in positive ways (Capozzoli and Rogers, 1996; Klassner and Anderson, 2003).

The aim of this study was to reveal to what extent the perceptions of scientists in the students' minds changed after experiencing a Lego Mindstorms EV3 based robotic education intervention. It was envisaged that students would change their perceptions of scientists and would increase their motivation and interest in the field of science and thus more likely to plan a future career in science and technology.

LITERATURE REVIEW

Science Education Aspect

In many countries, science and technology education is considered an important driving force in the socioeconomic and scientific and technological progress of the countries. Behind, the tremendous development of scientific and technological research in developed countries is the science and technology education and qualified workforce available to that country. However, despite the academic success of science students in international comparative studies (i.e., program for international student assessment, trends in international mathematics and science study), their attitudes toward science and affective areas such as making a career in science show a negative situation. Studies in the field of science education have investigated the underlying problems of this dilemma (Hofstein et al., 1990; Ornstein, 2006; Osborne et al., 2003; Sadi and Cakiroglu, 2011).

In the European Union (EU), many studies are being carried out to address these problems and reports are being published. For example, in the report entitled "Europe needs more scientists: EU blueprint for action" published after the EU high-level expert group study (Gago et al., 2004), the importance of increasing the number of young people working in the field of science in Europe was mentioned. In this report, it was mentioned that governments should play active role in the development of the skills of people to be raised in this field (Gago et al., 2004). In the 2007 report, "Science Education NOW: A Renewed Pedagogy for the Future of Europe" known as the Rocard (2007) report; recommendations were made for the use of the inquiry-based science education method in learning and teaching environments and for the development of activities aimed at increasing children's interest and attainments in science. These two reports highlight the importance of improving students' academic achievement and increasing motivation of students' by changing the teaching and learning environments and activities.

In a report published in 2014 by EU (Hazelkorn, 2015), the approach of including all social actors in the research and innovation process was internalized. The report also provided information that EU must provide the space for open, inclusive, and informed discussions on the research and technology decisions that influenced its citizens' lives.

Lammy et al. (2017), "*Lab - Fab - App,* investing in the European Future we want," were prepared by an independent high-level group. Its intention was on maximizing the impact of EU research and innovation programs. The report summarized 11 strong recommendations to increase the impact of future EU research and innovation programs. These recommendations were then followed with key actions. The third recommendation "*Educate for the future and invest in people who will make the change Action: modernize, reward and resource the education, and training of people for a creative and innovative Europe*" noted the importance of creating better teaching and learning environments. The eighth recommendation was "*Mobilize and involve citizens Action: stimulate codesign and cocreation through citizen involvement*" also clearly indicated that citizens should be involved in the research and innovation process (Lammy et al., 2017).

The latest report published by the Education, Audiovisual and Culture Executive Agency (Education and Youth Policy Analysis) (European Union, 2019) is "Digital Education at School in Europe." This report was an analysis of national-level data using a comparative approach. The focus included the development of digital competence through school curricula, teacher-specific digital competences, the assessment of students' digital competences and the use of technology in assessment and testing, and finally the strategic approaches to digital education across Europe with specific reference to policies supporting schools. The concepts of STEM, robotics, and educational robotics (ER) were issues mentioned in the report. For example, in Hungary, there was at least one special computing room and one programmable robot for every three students as well as every teacher had a laptop allowing them to prepare digital lessons and to carry out digital education administration. Another example from this report was the inclusion of computational thinking, ERs, and STEM/STEAM being planned in the Greek Curriculum.

As can be seen from the above reports, studies on research and innovation, which are seen as an integral part of the society members, are now coming to the fore. One of the important issues discussed in this respect is the concept of citizen science. In particular, the studies on the perception of the society and the integration of the society into science and innovation processes have gained incredible speed.

In this process, it has noted the importance of initiatives investigating our perceptions of scientists. The target group that needs to be prioritized in this research should be those young individuals who will shape our society in future. Mead and Metraux (1957) conducted one of the first studies on the perceptions of scientists and the studies. They found that the perceptions of scientists were as follows: *Wearing a white coat, working in the laboratory*, *wearing glasses*, *being mostly bearded*, *having an environment equipped with tools such as test tubes*, *spending his/her days by experimenting*, *and being men*.

In the current study, it was aimed to investigate the perceptions of scientists in the minds of young individuals who will shape the future of society. It was thought that by knowing the perceptions of scientists in their minds, the motivation and interest of the future generations to make a career in science and technology could be increased. This situation, naturally, will also help science and technology educators to create better formal and informal learning environments.

Perceptions about Scientists – Draw a Scientist Test (DAST)

In recent years, students' perceptions of scientists have been one of the important research fields in science education. Many studies have found that students' perceptions of scientists seem to be related to future career choices, attitudes toward the study of science, and their participation in science classrooms (Faye-Neathery, 1997; Finson et al., 1995; Mason et al., 1991; Medina-Jerez et al., 2011; Tobin and Fraser, 1987). Chambers first measured student perceptions of scientists in 1983 using the "DAST." DAST was developed as an open-ended projective test, in which children's drawings were rated according to particular characteristics present or absent in their drawings (Finson et al., 1995). Pictures were assessed according to seven, basic standard image elements including laboratory coats, eyeglasses, facial growth of hair, symbols of

Science Education International
31(1), 92-103
https://doi.org/10.33828/sei.v31.i1.10

research (i.e., beakers), symbols of knowledge (i.e., books), products of science (i.e., rockets), and captions (i.e., "eureka"). Chambers (1983) and Schibeci and Sorensen (1983) found that children's images of scientists become more stereotypical as they progressed through successively higher grade levels, and that by the fifth grade, the stereotypical "image" had fully emerged (Thomas et al., 2001). In 1995, Finson, Beaver, and Crammond developed the DAST checklist (DAST-C) to increase the objectivity and reliability of the DAST that each item represents a standard stereotypic characteristic. The DAST-C identified eight additional "alternative" characteristics including male gender, Caucasian, indications of danger, light bulbs, mythic stereotypes (i.e., mad crazed, Frankenstein), indications of secrecy, working indoors, and middle aged or elderly. Despite the fact that these instruments (DAST and the DAST-C) are both useful tools for gaining insight into the students' concepts of scientists. Finson et al. (1995) identified two cautions in the use of these instruments. One of them was that students may have more than one definition of the word scientist and this could result in students drawing different images at different times without having their perceptions changed by a particular treatment. The other one was that changing the wording in directions given to students could alter the types of drawings produced.

DAST has been applied to different populations and different countries. Some of these studies focused on children of different ages, university students, and teachers. These studies revealed that students possess interesting stereotypical images of scientists (Chambers, 1983; Finson et al., 1995; Fort and Varney, 1989; Huber and Burton, 1995; Schibeci and Sorensen, 1983). Although the perceptions of the scientist occur in early childhood, adults and even scientists themselves present similar stereotypes in their drawings (Chambers, 1983). Students generally perceive scientists as being White males and working alone in a laboratory. Many DAST studies showed that students' images of scientists include elderly, White scientists and doing science indoors (Meyer et al., 2019). Although some mythical stereotypes such as "Mad Scientists" or "Frankenstein"-like creatures have been reported by early studies (e.g., Mead and Metraux, 1957), they do not seem to be a common feature anymore.

Robotics and Lego Mindstorms

During the past decade, robotics has been a growing field that has the potential to significantly impact the nature of engineering and science education at all levels and to support learning in science, mathematics, technology, informatics, and other school subjects or interdisciplinary learning activities (Alimisis, 2013; Mataric, 2004). Robots started to become an important issue in education when Papert introduced the programming language LOGO and the floor turtle – a robot that can execute commanding directions by connecting to a computer (Altin and Pedaste, 2013). With the development of motion sensing technologies, the usage of these technologies in education could not only transform a student into a young programmer who thinks, designs, evaluates, reflects, and adjusts solutions but also enhance young students' motor skills and introduce new ways of problem-solving skills development (Kandroudi and Bratitsis, 2013). ER systems consist of building material and software facilities that allow the construction and the programming of various robots from smart cars to chimney cleaners. Robots have sensors and machines like motors. They collect data from their environment and use them as parameters. An important feature of this technology is that it can be very simple to use for constructing a model and programming it (Frangou et al., 2008). The LEGO laboratory began with investigating how to make the interaction in games with three different kinds of intelligent agents; the child, the robot, and a computer game (Lund, 1999).

Lego Mindstorms was originated by Papert's studies at the MIT Media laboratory in 1998. Lego robotics is one of the inspiring educational toys and the philosophy of its design comes from constructivism and Seymour Papert's constructionism. Lego robotics allow to students to learn the knowledge of mathematics and science by designing and manipulating the Lego robotics. Using this toy, children can develop problem-solving ability and creativity in the thinking process (Shih et al., 2013). Lego Mindstorms is a series of robotic structures where robots, tools, and interactive elements can be created by combining traditional Lego parts with programming knowledge. The Lego Mindstorms EV3 set includes motors, sensors, programmable bricks (small computer), cables, remote control, and other technical elements. It enables users to transform a robot they have created into a structure that can perform various functions through the programming language. The language necessary for programming is very understandable it can run on both Windows and Mac operating systems. Various experimental designs that can be used in science education can be realized with smart tools and robots developed. It is used as an effective and important tool for students to start programming. Lego Mindstorms is now a line of programmable robotics/construction kits that include 619 pieces such as programmable sensor blocks (touch, light, sound, and distance) and EV3 Intelligent Brick. The latest version powered by the new EV3 Intelligent Brick – Lego Mindstorms EV3 released in 2013. The latest version allows students to control the behavior of a tangible model by means of a virtual environment and conduct science experiments, in which young students investigate a socio-scientific issue using their scientific process skills both in and out of the classroom (Resnick et al., 1996). For example, a young student struggling in science and math courses might focus and concentrate on the mathematics and science skills needed to program a robot that will move in a desired manner (Garrigan, 1993; Rogers, 2010).

Few studies have been conducted related to the field of ERs and these studies were quantitative in nature (Altin and Pedaste, 2013). Although the usage of robotics in classrooms is positive in general, more detailed studies should be done. Eguchi (2014) states that robotics education is an extremely important tool for learning, computational thinking, coding, and engineering, which are the main objectives of STEM

Science Education International
31(1), 92-103
https://doi.org/10.33828/sei.v31.i1.10

philosophy. Sipitakiat (2000) and Shih et al. (2013) stated that Lego-based educational activities attract the attention of schoolchildren and build an environment of convivial learning. Alimisis (2013) examined constructivist pedagogical and methodological methods that should be applied by robotic trainers working in school education. In their study, Stormont and Chen (2005) made various suggestions about traditional approaches used in mechatronics and robotics education, as well as robot laboratory experiments and mobile robots. Atmatzidou et al. (2008) investigated the effectiveness of Lego Mindstorms in understanding the basic concepts of programming through play activity in their work. They carried out their research in a way that emphasizes the element of competition between primary and secondary school students. Mikropoulos and Bellou (2013) stated that robotic education is one of the tools of mind that promotes constructivism. In this context, students investigated the processes of developing meaningful robotic designs, developing learning processes by confronting cognitive designs, and strengthening learning in both virtual and real world through positive learning, physics, and programming teaching. Afari and Khine (2017) provided information on how and with which strategies Lego Mindstorm kits should be used in schools. There are studies, which tried to obtain evidence about the impact of Lego Mindstorms on the students' achievements. For example, Cavas et al. (2012) investigated the impact of a Lego Mindstorms based robotics course, operated as an after school club on the sixth and seventh grade students' achievements of science process skills, scientific creativity, and their perceptions on robots, humans, and society. The results of their study showed that the robotics club increased students' skills in scientific creativity and science process skills. These researchers reported that the students changed their perceptions of robots, humans, and society in a positive direction. Furthermore, several gender differences were found from administering the instruments and seeking perceptions.

METHODOLOGY

Instrument

In this study, a modified version of the DAST-C was used to assess students' stereotypes of scientists before and after robotic education. The instrument of DAST-C was designed to collect data related to 12 stereotypes of scientists (Meyer et al., 2019). These stereotypes were the gender of the scientist in the drawing (male, female, and not identifiable), whether the drawing had features of elderly person, whether the person wore a laboratory coat, eyeglasses/laboratory goggles, had "crazy" hair, was bald, and had facial hair, whether there was any writing equipment (writing utensils and clipboard), whether there was laboratory equipment (physics and biological laboratory equipment, laboratory animals), and whether there were educational features (e.g., whiteboard, workbench, and periodic table), mathematical equations, and/or expressions. A prepared blank sheet of paper was given to each student and they were asked to draw a scientist. Furthermore, some demographic variables such as age and gender were asked to students. The procedure of drawing a scientist lasted for about 25 min. All students in the study received the same instructions for completing the activity, and a standardized procedure was put in place for data collection.

Participants

Twenty-one students from 5th, 6th, and 7th grades attending a private school participated in this research. The students were aged between 11 and 13 and consisted of 15 girls and 6 boys. The school is located on the campus of Dokuz Eylül University. Students arrive at school at 9:00 in the morning and continue until 16:00 in the afternoon. The school has 23 different types of student clubs. Students select these clubs according to their own preferences. One of these clubs is the robotics club. All of the students participating in the study were students of this club. Lego robotics education activities of this club were carried out at the distance education application and research center of Dokuz Eylul University. In addition to being a center responsible for all distance education activities of the university, Distance Education Application and Research Center also provides technological training to the university and its related units. Within the scope of this study, students continued their studies in the research laboratories of Distance Education Application and Research Center with four experts (scientists on robotics and technology-supported education). In addition, the school's computer teacher responsible for this club also took part in all the work. The data were collected during 2018–2019 teaching semester.

Procedure

Robotic education program – content

In the course of robotic education, first, the Lego Mindstorms EV3 set was introduced to the students and the necessary explanations were made for the purposes of this training and the achievements of the training. Then, Lego Mindstorms EV3 box contents were introduced to the students and students were allowed to examine the box contents. A 26-page robotic training booklet was prepared for the students to follow the training activities and these booklets were distributed to all the students. Sample screenshots of the developed booklet are shown in Figure 1.

This booklet contains eight modules:
Module 1: Introduction to robotics
Module 2: Introduction to programming in robotics
Module 3: Making a simple robot
Module 4: Programming with line tracking method
Module 5: Rotation programming using sensor
Module 6: Object recognition programming operations
Module 7: Sound generation at specific intervals
Module 8: Effect of robotics on preventing traffic accidents.

After examining the boxes, students were informed about what elements such as bricks, cables, and sensors were and what could be done with these objects. Afterward, the students were informed about what programming was in general and for what purposes it was used and then the basic functions of the software to be used in programming were introduced. After explaining the basic functions of the software used in Lego programming, the construction of a simple robot was demonstrated by the instructors and then the students were divided into four groups. The groups were asked to do the same activity by following the instruction booklet. After this process, the students were asked to do the Module 1 in the training booklet. The same process was followed for the following seven modules and students were asked to address the problem that was presented to them in Module 8. The last module was at a level where students could apply the knowledge they had learned in other modules.

During the training process, inquiry-based learning methodology was used. More details are presented below about inquiry-based learning.

Inquiry-based Learning

Inquiry is an approach that positively encourages the investigation of real questions whenever they are asked. The characteristic of the inquiry approach is to take into account the entire transient answers and to carry out a thorough investigation to the extent permitted by the circumstances. In the inquiry approach, it is stated that the questions asked have importance and if the students determine this importance, a more positive development is expected scientifically (Cavas et al., 2013). The levels of inquiry-based learning were carried out in three different ways. Table 1 shows these settings and the levels at which the modules in the study performed.

In the given robotic education, Modules 1, 2, and 3 were conducted at structured inquiry level, while Modules 4, 5, 6, and 7 were at guided inquiry level. Module 8 was at open inquiry level. Students were given a problem-based topic and were expected to solve this problem using Lego Mindstorms EV3 kits. As a result, students tried to find solutions to the same problem with different types of methods.

Analysis of Drawings

In this study, science and technology education experts analyzed the students' drawings. A content analysis was conducted for analyzing the students' images of scientists. In the analysis procedure, the way used by Meyer et al. (2019) was taken into account. In this study, a modified version of the DAST-C was used to assess 12 stereotypes of scientists that were all collected as dichotomous variables: The gender of the scientist in the drawing (male, female, and not identifiable), whether the drawing had features of elderly person, whether the person wore a laboratory coat, eyeglasses/laboratory goggles, had "crazy" hair, was bald, and had facial hair, whether there was any writing equipment, whether there was laboratory equipment, and whether there were educational features, mathematical equations, and/or expressions (Meyer et al., 2019). The drawings of the participants were coded as one for the presence of the stereotypical component it displayed.

Interobserver agreement (IOA) was used for this analysis. IOA is a procedure for enhancing the reliability of data that involve comparing independent observations from two or more people of the same events. IOA is computed by taking the number of agreements between the independent observers and dividing by the total number of agreements plus disagreements. The coefficient is then multiplied by 100 to compute the percentage of agreement. Each independent expert made analyzed each drawing and reached consensus by working with another independent expert on the data. After reaching the same consensus in the two independent team of experts,

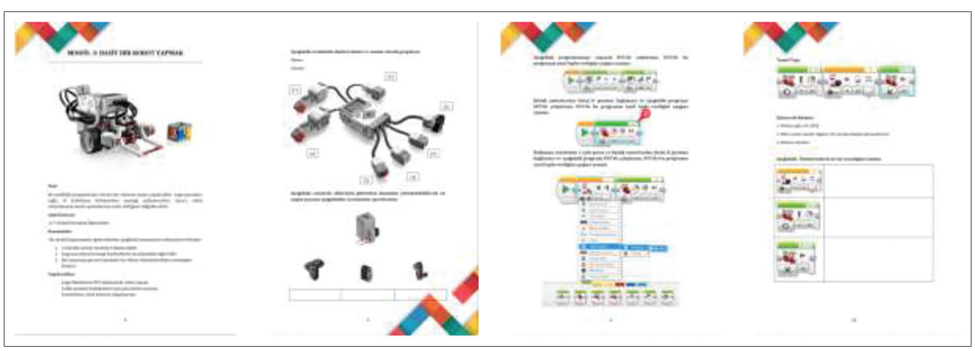


Figure 1: Robotic education booklet screenshots

Table 1: Different settings of inquiry learning

Model of inquiry learning	Question investigated presented/posed by	Procedure prescribed/ designed by	Procedure for data analysis/ interpretation and making conclusion	Lego education modules in inquiry teaching levels
Structured inquiry	Presented by teacher	Prescribed by teacher	Procedure teacher directed and prescribed; student interpreted	Module 1,2,3
Guided inquiry	Usually presented by teacher	Usually designed or selected by students	Usually teachers guided, but student interpreted	Module 4,5,6,7
Open-inquiry	Posed by students	Designed by students	Student-led procedures and interpretation	Module 8

Cavas et al., 2013

Science Education International
31(1), 92-103
https://doi.org/10.33828/sei.v31.i1.10

the consensus was achieved by comparing the data of the two independent groups of experts. As a result, four different independent experts reached the final agreement.

Coherence between independent observers is a criterion of reliability applied when multiple observers try to measure the same things independently. It is known as the best criterion for predicting the reliability of measurement, especially where other reliability measures are impractical. In such measurements, there is a single value for each case, taking the average of the measurements taken by the observers separately. The main thing is the reliability of this value. The calculated overall IOA among independent observers was 87%, which is greater than 80%.

RESULTS

In this study, it was aimed to investigate what kind of changes would be observed in the perception of scientists after an intervention robotic education. The relationship between pre- and post-drawings (Figures 2 and 3) was examined using a single group pre- and post-test model. Table 2 shows the frequency analysis of the data obtained from the students depending on the grade level. The results are reported based on the data obtained from the preliminary and final drawings.

Based on the findings from the total results of Table 2, it is possible to reach the following results:

While the students drew more male scientists in the pre-test (76%), it was seen that there was a significant decrease (52%) in the post-test. In the drawings, as the scientists were mostly turned around and facing the computer, their gender could not be determined exactly. As a result of the robotic education, it was found out that the students were reflected in the perceptions of scientists as people looking for solutions to problems.

In terms of scientists' age perception, students tended to draw older scientists in their preliminary drawings (33%); in their latest drawings, this was reduced (14%). In general, age characteristics of scientists from students' drawings were not fully understood which was one of the results obtained from the analysis of the data obtained (62% and 52%, respectively).

Two of the unchanging situations in the students' perceptions for the students participating in this study were the scientists in laboratory coats and wearing protective laboratory glasses. The preliminary and final drawings show similar results. The number of laboratory coats drawn in the first and final drawings of the students was the same (6%). When the data about the protective laboratory glasses used by scientists were analyzed, 33% of the students drew that at the beginning, but it decreased to 24% in their last drawings.

One of the striking results obtained from the study was related to the physical properties of scientists. While the first drawings of the students had more crazy hair (48%), bald/no hair (19%), and beards (24%), the last drawings showed that these physical properties decreased dramatically (24%, 10%, and 5%, respectively). For example, the number of students who drew crazy hair was reduced by half.

Some of the points considered in the drawings were writing equipment, laboratory equipment, educational features, equations, and expressions. It was found that students used these features more in their post-drawings for scientists. The use of the aforementioned features during robotic education has shown that students' perceptions of scientists significantly changed. In the preliminary drawings, just over half of students (52%) drew writing equipment while it increased to 86%. Regarding laboratory equipment, 90% of the students used these in their first drawings, while in the final drawings, all of the students included laboratory equipment. Some changes were also observed in the educational features that the students used in their drawings. In the initial drawings, 86% of the students depicted educational characteristics, while this ratio increased to 90% in the final drawings. While the equations in the students' preliminary and final drawings remained the same (14%), there was a partial increase in expressions (from 52% up to 62%).

How the physical properties (bodies) of scientists were drawn in the study was one of the topics discussed in this research. In the first drawings, the students made drawings that revealed the whole body of the scientists, while in the last drawings, it was seen that instead of drawing the bodies completely, the scientists were drawn at a desk. However, it was concluded that the students who initially tended to draw stick figures depicted characteristics that revealed more prominent body features. While the percentage of students who used full body in their pre-drawings was 86%, this situation decreased to 52% in the final drawings. On the other hand, 5% of those who used half figures in their preliminary drawings increased to 19% in their last drawings. Only one student used a single head in his preliminary drawings. There were no drawings with a single head for scientist in students' drawings. In the preliminary drawings, the percentage of students who drew a stick figure was 48%, while this situation decreased to 24% in the last drawings.

The last feature examined in the study was the facial expressions of scientists. In the beginning, the students drew more friendly facial expressions (57%). In the last drawings, the percentage of students who had friendly faces decreased by 19%. One of the interesting results obtained from this study was that although no student had initially drawn an unfriendly face, in the last drawings, it was seen that two students drew an unfriendly expression. Neutral facial expression was found to be constant in the pre- and post-drawings (14%). While 24% of the students did not use significant facial expressions (not identifiable) in their preliminary drawings, this ratio increased to 57% in the final drawings.

DISCUSSION

This study investigated the extent to which the perceptions of scientists in school students' minds change after a robotic education. The data of this study were collected through pre- and post-students' drawings just before and after the

Science Education International
31(1), 92-103
https://doi.org/10.33828/sei.v31.i1.10

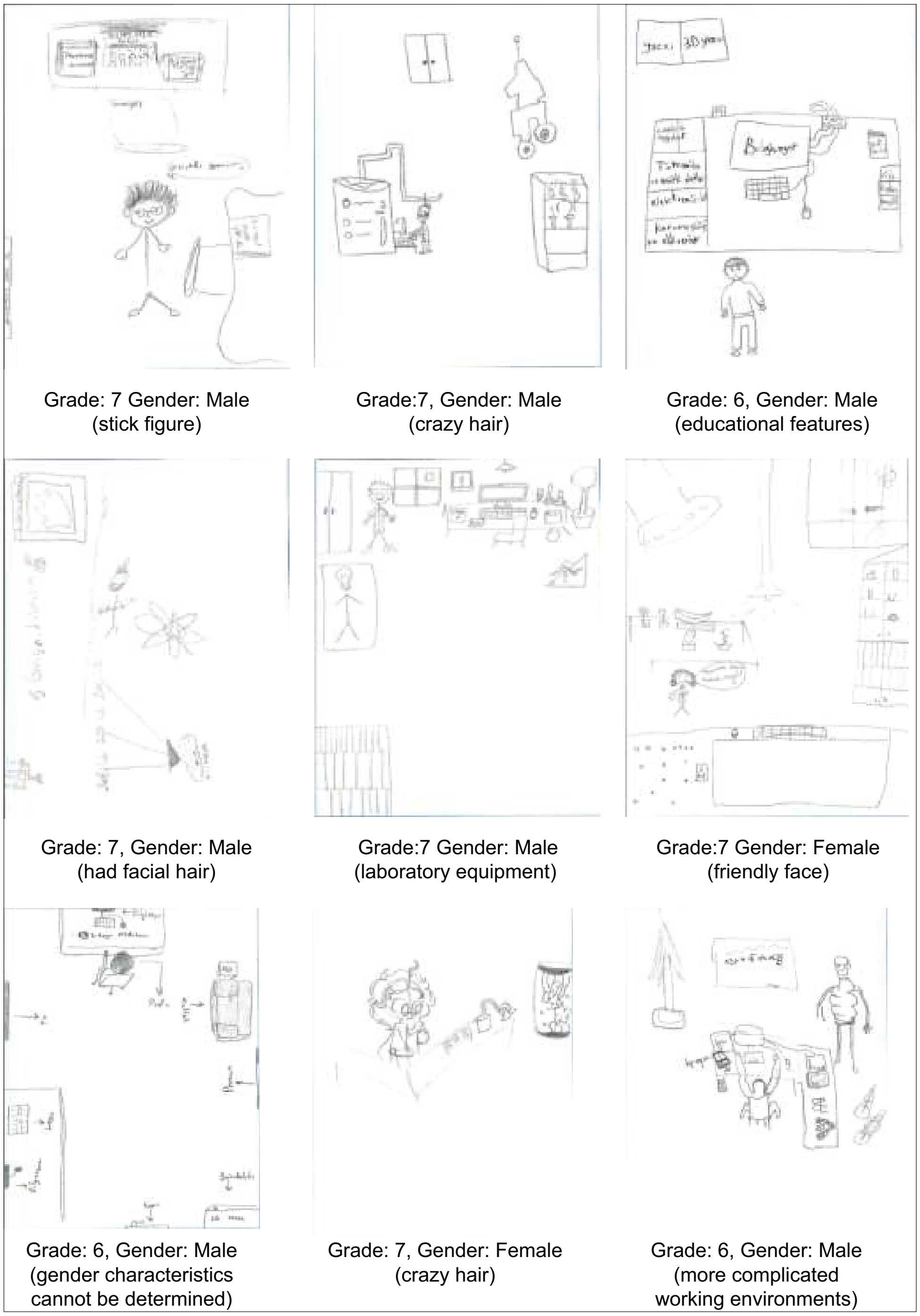


Figure 2: Pre-pictures drawn by students for their imagination about scientists

robotic education provided by distance education center of a state university located in Turkey. DAST-C checklist was used to analyze the data by researchers.

Research has been conducted on students' perceptions about scientists. Most of these researches were conducted on one student group at different educational levels and different age groups. The results obtained from these studies were based on the analysis of the collected data. The current study used a pre- and post-test single group to see the effects of robotic education on the students' perception about scientists. It was seen that there are very few studies, in which pre- and post-test single or control group patterned model was applied in this field. From this point of view, this study sheds new light in terms of results and data.

The general results obtained from this study show that the students:

- Focused less of scientists' gender after robotic education
- Perceptions about the age of scientists changed and they placed more emphasis on working environments than the age

Table 2: Frequency analysis of the data obtained from the students depending on the grade level

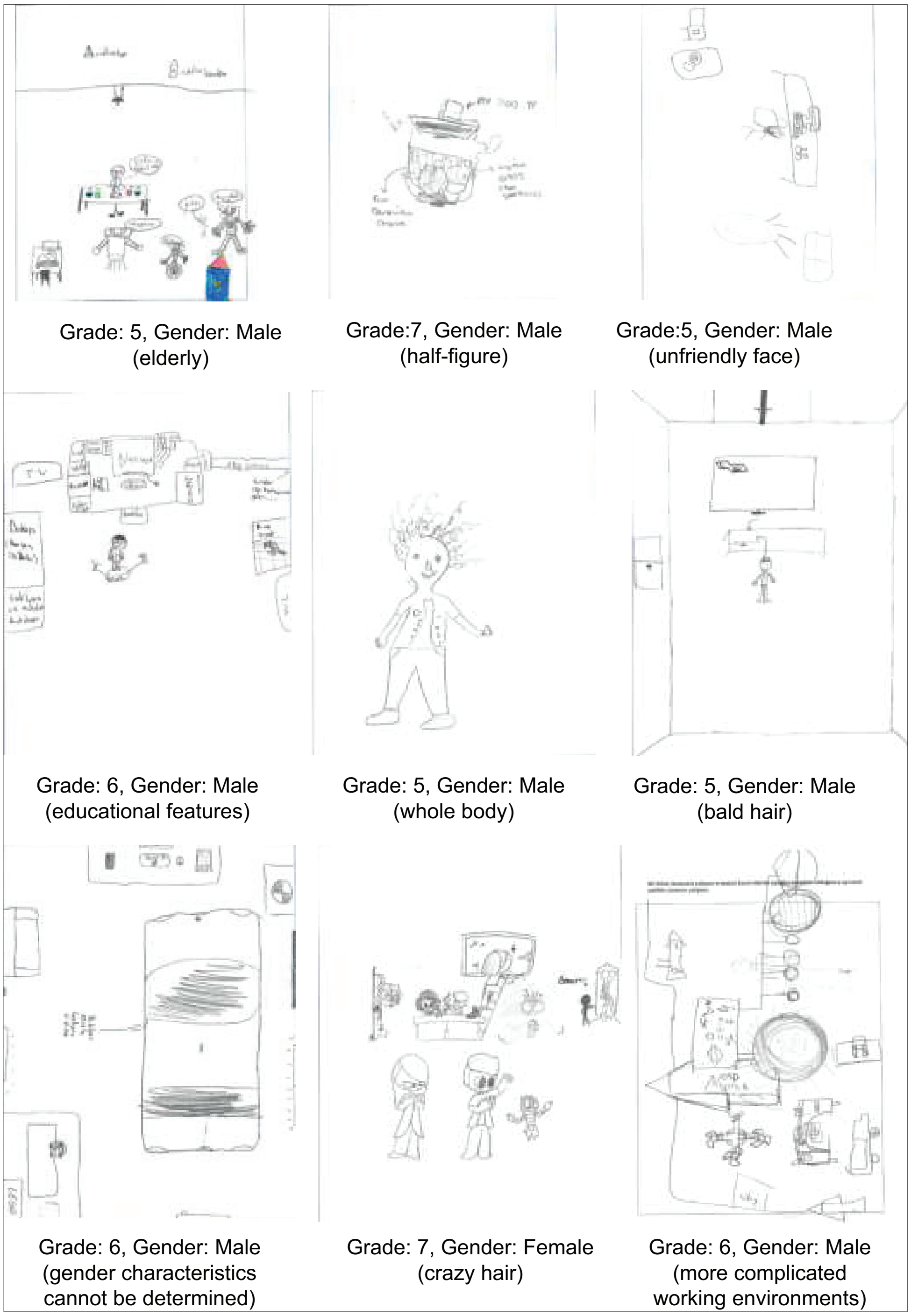
Descriptives	Grade 5				Grade 6				Grade 7				Total			
	Pre-test		Post-test		Pre-test		Post-test		Pre-test		Post-test		Pre-test		Post-test	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Gender																
Female	1	5	0	0	0	0	0	0	2	10	2	10	3	14	2	10
Male	5	24	5	24	5	24	1	5	6	29	5	24	16	76	11	52
Not identifiable	1	5	0	0	0	0	3	14	1	5	1	5	2	10	4	19
Age																
Elderly	3	14	2	10	1	5	0	0	3	14	1	5	7	33	3	14
Not identifiable	4	19	2	10	4	19	4	19	5	24	5	24	13	62	11	52
Wear																
Laboratory coat	1	5	3	14	1	5	1	5	4	19	2	10	6	29	6	29
Eyeglasses/laboratory glasses	1	5	2	10	1	5	1	5	5	24	2	10	7	33	5	24
Physical properties																
Crazy hair	3	14	3	14	1	5	0	0	6	29	2	10	10	48	5	24
Bald/no hair	1	5	2	10	2	10	0	0	1	5	0	0	4	19	2	10
Had facial hair	2	10	1	5	1	5	0	0	2	10	0	0	5	24	1	5
Research symbol																
Laboratory equipment	7	33	7	33	4	19	5	24	8	38	9	43	19	90	21	100
Educational features	5	24	6	29	4	19	5	24	9	43	8	38	18	86	19	90
Equations	0	0	0	0	1	5	1	5	2	10	2	10	3	14	3	14
Expressions	3	14	2	10	3	14	4	19	5	24	7	33	11	52	13	62
Figure type																
Whole body	5	24	5	24	4	19	3	14	9	43	3	14	18	86	11	52
Half a figure	0	0	0	0	1	5	0	0	0	0	4	19	1	5	4	19
Only a head	1	5	0	0	0	0	0	0	0	0	0	0	1	5	0	0
Stick figure	3	14	3	14	1	5	2	10	6	29	0	0	10	48	5	24
Face situation																
Friendly face	4	19	2	10	2	10	1	5	6	29	1	5	12	57	4	19
Unfriendly face	0	0	2	10	0	0	0	0	0	0	0	0	0	0	2	10
Neutral face	2	10	1	5	0	0	0	0	1	5	2	10	3	14	3	14
Not identifiable	1	5	2	10	3	14	4	19	1	5	6	29	5	24	12	57

- Drew less scientists in laboratory coats
- Drew different types of scientists when compared to the stereotype scientist (i.e., bald/no hair, beard, etc.)
- Use more laboratory equipment, equations, and educational equipment.

One of the important outcomes of this study was in how students drew scientists sitting at a desk working in their post-drawings. Another important finding was that there were some negative traits in the facial perceptions of scientists after the robotic education.

One of the major results of the study was that students used more laboratory equipment, equations, and some educational equipment in their last drawings. When other studies in this field were examined, the results obtained show similar results, especially with the use of laboratory equipment (Chambers, 1983; Maoldomhnaigh and Hunt, 1988; Newton and Newton, 1998). It can be thought that the students were affected by documentaries, cartoons, or even computer games they had played. However, the special findings obtained from this study show that students used some features such as laboratory equipment, educational features, and expressions after their robotic training, though partially in their drawings. It was seen that there was a partial change in students' perceptions after robotic training. As revealed in many studies, the elimination of the stereotype scientist images in the minds of students should be an important action. During learning process, students should be taught that a scientist does not only work in closed laboratories with their laboratory coats, but sometimes in nature and sometimes of other parts of the building. For this process, it is important to direct the educational clubs to be created according to the interests of the students and to create environments that can work with real scientists.

According to the pre-test and post-test pictures, the number of students depicting scientists as old in the pre-test pictures was seven, whereas this number decreased to three in the post-test pictures drawn after robotic education. It is thought that this may have been shaped according to the age, appearance, or teaching style of the instructors with the students. In the pre-test, 33%of the students portrayed scientists as the elderly, whereas in the post-test pictures, this ratio decreased to 14%.



Grade: 5, Gender: Male (elderly) | Grade:7, Gender: Male (half-figure) | Grade:5, Gender: Male (unfriendly face)

Grade: 6, Gender: Male (educational features) | Grade: 5, Gender: Male (whole body) | Grade: 5, Gender: Male (bald hair)

Grade: 6, Gender: Male (gender characteristics cannot be determined) | Grade: 7, Gender: Female (crazy hair) | Grade: 6, Gender: Male (more complicated working environments)

Figure 3: Post-pictures drawn by students for their imagination about scientists

While the number of students depicting scientists with a happy expression was 12 in the pre-test drawings, this number decreased to four in the post-test pictures drawn after the training. This can be stated as an undesirable condition. When analyzed proportionally, this value decreased from 57% to 19%. In the pre-test results, the number of unhappy scientists was zero, whereas in the post-test pictures, this number increased two and this value represents 1% in all drawings. The number of scientists whose facial expression was neutral (neither happy nor unhappy) was determined to be three in both pre-test drawings and post-test pictures. Of all the drawings, this value has a rate of 14%. In addition to these results, the number of scientists who have meaningless facial expressions increased from 5 to 12 (from 24% to 57%). According to the results of many studies in the literature, students stated that scientists are not cold looking and friendly (Pekdoğan and Bozgün, 2019).

When the gender of the scientists drawn from the pre-test and post-test drawings is examined, the number of students describing the scientist as woman in the pre-test drawings was three, and this number was two when the post-test pictures were examined. According to the results obtained from the pre-test pictures, the number of students who portrayed male scientists was 16, while the number of students who portrayed scientists as men in the post-test pictures decreased to 11. Proportionally, the percentage of students who think that the scientists of their perception were men declined from 76% to 52%. When the drawings of the male and female students in the experimental group were examined separately, the number of male students who drew the scientist as male was 13 while this number decreased to 10 in the post-test pictures. There was a decrease in proportion from 86% to 76%. Despite this decrease, there is no increase in the number of paintings drawn as a female scientist. It can be thought that the reason for this is that the idea of transforming the working environment of the scientist into robotic environments without being dependent on people has formed in the perceptions of the students. When examined in terms of female students, the proportion of female students describing the scientist as female in the pre-test pictures was 33% female, the proportion of female students describing the scientist as male, and the percentage of female students describing the scientist whose gender cannot be understood was 17%. In the post-test pictures, the rate of female students who draw scientists as women was 50%, the rate of female students who drew scientists as men was 25%, and the proportion of female students who drew scientists whose gender could not be understood was 25%. Buldu, 2006, states that all students drew male scientists. There are many different studies state that the majority of scientists are described as men (Fung, 2002; Christidou, 2011). The results of this study revealed that the students can describe the gender of scientists as women. Moreover, after robotic education, the proportion of female students who portrayed scientists as women increased from 33% to 50%. This may be due to the fact that one of the trainers providing robotics training is a woman.

In the pre-test pictures of the students, there were 17 students who used character-specific concepts such as glasses, hair, beard, hat, and smile, while the number of students using these concepts decreased to 13 in the post-test pictures. While the number of students using technology-related concepts such as computer, keyboard, and 3D printer in the pre-test pictures was 10, the number of students using these concepts in the post-test pictures increased to 16. This was desirable. It is possible to say that the robotics education caused an increase in students' perception of technological concepts. In the pre-test pictures, the number of students who visualized the concepts of a dream world such as nuclear waste car, drone flying car, and hologram computer in their paintings was two, while the number of students using these concepts in post-test pictures was 11. This was also a desirable result. It is also possible to say that the robotic education may have contributed to the perceptions students create in their imagination.

CONCLUSION AND SUGGESTIONS

It has been reported that the results obtained from studies on students' perceptions of scientists have similar characteristics (Chambers, 1983; Schibeci and Sorensen, 1983; Makarova and Herzog, 2015; Mason et al., 1991; Newton and Newton, 1998). This study investigated the change in students' perceptions of scientists after having experienced a robotic education intervention. The results showed that students' perceptions had been changed and new alternative perceptions were gained by these students.

In many schools around the world, students get passive information from their teachers during their classic educational processes. It is clear that students do not get enough knowledge of scientists' daily lives, working environments, projects, and discoveries during their primary and secondary education. As a reason for this, students keep similar perceptions of scientists in their minds. The importance of this situation has been reflected in the reports in the EU and calls for necessary investments have been prepared. The best known of these is the Researchers' Night event, which is supported by the Marie Curie Program of the EU (Cavas et al., 2019). The result of this study highlights that students' perceptions of scientists can be changed by creating new and smart teaching and learning environments, in which they can work with scientists in out-of-school learning environments to solve socio-scientific problems in today's world.

There is a need to change educational policies, in which students can be arranged to meet with scientists in out-of-school settings. EU's Science with and for Society (SWAFS) program funds such purposes (Cavas, 2015). For example, the open schools for open societies project are one of these projects. It is possible to carry out scientific activities using out-of-school environments through an educational platform developed for students, teachers, scientists, and all stakeholders (Sotiriou and Cherouvis, 2017).

The Lego Mindstorms EV3 kits, which were used as a supportive educational tool in this study, provided students opportunities to learn how to use robotic technologies to solve socio-scientific problems after learning robot building, programming, and coding. In this respect, Lego Mindstorms EV3 kits can be thought of as important educational tool to contribute to this digital transformation process in education. As a negative point, it should be noted that these kits are expensive educational tool for many schools.

As a final remark, the collection of new evidence supported by the qualitative research methods would provide important clues in the formation of new educational policies and future reforms to change students' scientist images in their mind and their career choices in science and technology fields.

ACKNOWLEDGMENT

This research was supported by Dokuz Eylul University Scientific Research Unit with the number of 2016.KB.EGT.001. The authors especially thank the DEU 75.Yil Primary Education School's students and administrative staff for permission to implement the study in the school. Lego Mindstorms is a

trademark of The Lego Group. None of the authors of this article has any financial relationship with the Lego Group.

REFERENCES

Afari, E., & Khine, M. (2017). Robotics as an educational tool: Impact of lego mindstorms. *International Journal of Information and Education Technology*, 7(6), 437-446.

Alimisis, D. (2013). Educational robotics: New challenges and trends. *Themes in Science and Technology Education*, 6, 63-71.

Altin, H., & Pedaste, M. (2013). Learning approaches to applying robotics in science education. *Journal of Baltic Science Education*, 12(3), 365-377.

Atmatzidou, S., Markelis, L., & Demetriadis, S. (2008). The Use of LEGO Mindstorms in Elementary and Secondary Education: Game as a Way of Triggering Learning. Venice, Italy: *Proceedings of SIMPAR 2008 International Conference on Simulation, Modeling and Programming for Autonomous Robots*. p22-30.

Bernard, P., & Dudek-Różycki, K. (2017). Revisiting students'' perceptions of research scientists: Outcomes of an indirect draw-a-scientist test (InDAST). *Journal of Baltic Science Education*, 16(4), 562-575.

Buldu, M. (2006). Young children's perceptionsof scientists: A preliminary study. *Educational Research*, 48(1), 121-132.

Capozzoli, P., & Rogers, C. (1996). LEGOs and Aeronautics in Kindergarten through College. New Orleans, LA: *Proceedings of AIAA 19th Advanced Measurement and Ground Testing Technology Conference.*

Cavas, B. (2015). A new challenge by The European Union has already started: Responsible research and innovation. *Journal of Baltic Science Education*, 14(3), 292-294.

Cavas, B., Holbrook, J., Kask, K., & Rannikmae, M. (2013). Development of an ınstrument to determine science teachers' implementation of ınquiry based science education in their classrooms. *International Online Journal of Primary Education*, 2(2), 9-22.

Cavas, B., Kesercioglu, T., Holbrook, J., Rannikmae, M., Ozdogru, E., & Gokler, F. (2012). The Effects of Robotics Club on the Students' Performance on Science Process and Scientific Creativity Skills and Perceptions on Robots, Human and Society. Trento, Italy: *Proceedings of 3rd International Workshop Teaching Robotics, Teaching with Robotics Integrating Robotics in School Curriculum Riva del Garda.*

Cavas, B., Oral, L., & Karagöz, E. (2019). European scientists night program at science centers. In: Köseoğlu, F., & Kanlı, U. (Eds.), *Learning Journey Beyond School Walls*. Ankara: Nobel Publishing Company. p355-371.

Chambers, D. (1983). Stereotypic ımages of the scientist: The draw-a-scientist test. *Science Education*, 67(2), 255-265.

Christidou, V. (2011). Interest, attitudes and ımages related to science: Combining students' voices with the voices of school science, teachers, and popular science. *International Journal of Environmental and Science Education*, 6(2), 141-159.

Eguchi, A. (2014). Robotics as a Learning Tool for Educational Transformation. Padova, Italy: *Proceedings of 4th International Workshop Teaching Robotics, Teaching with Robotics and 5th International Conference Robotics in Education*. p27-34.

European Union. (2019). *Digital Education at School in Europe. Eurydice Report.* European Commission/EACEA/Eurydice. Brussels: Publications Office of the European Union.

Faye-Neathery, M. (1997). Elementary and secondary students' perceptions toward science: Correlations with gender, ethnicity, ability, grade, and science achievement. *Electronic Journal of Science Education*, 2(1), 7573.

Finson, K., Beaver, J., & Crammond, R. (1995). Development of a field-test of a checklist for the draw-a- scientist test. *School Science and Mathematics*, 95(4), 195-205.

Fort, D., & Varney, H. (1989). How students see scientists: Mostly male, mostly white, and mostly benevolent. *Science and Children*, 26(8), 8-13.

Frangou, S., Papanikolaou, K., Aravecchia, L., Monel, L., Ionita, S., Arlegui, J., Pagello, I. (2008). Representative Examples of Implementing Educational Robotics in School Based on the Constructivist Approach. Venice, Italy: *Workshop Proceedings of SIMPAR 2008 International Conference on Simulation, Modeling and Programming for Autonomous Robots*. p54-65.

Fung, Y. (2002). A comparative study of primary and secondary school students' images of scientists. *Research in Science and Technological Education*, 20(2), 199-213.

Gago, J., Ziman, J., Caro, P., Constantinou, C., Davies, G., Parchmann, L., Sjøberg, S. (2004). *Europe needs More Scientists: EU Blueprint for Action.* Available from: https://www.ec.europa.eu/digital-single-market/en/news/europe-needs-more-scientists-eu-blueprint-action. [Last accessed on 2020 Feb 03].

Garrigan, S. (1993). *A Comparison of İntrinsic Motivation Elicited in Children by Computer-Simulated Robots Versus Physical Robots*. Bethlehem, PA: Unpublished Ph.D Thesis, Leigh University.

Hazelkorn, E. (2015). *Science Education for Responsible Citizenship: Report to the European Commission of the Expert Group on Science Education.* Luxemburg: Publication Office of the European Commission.

Hofstein, A., Mooz, N., & Rishpon, M. (1990). Attitudes toward school science: A comparison of participants and non-participants in extracurricular science activities. *School Science and Mathematics*, 90(1), 13-22.

Huber, R., & Burton, G. (1995). What do students think scientists look like? *School Science and Mathematics*, 95(7), 371-376.

Kandroudi, M., & Bratitsis, T. (2013). An Overview of Game Console Motion Sensor Technologies Exploited for Education. Cork, Ireland: *Proceedings from the 7th European Conference on Games Based Learning*. p252-260.

Klassner, A., & Anderson, S. (2003). Lego mindstorms: Not just for K-12 anymore. *IEEE Robotics and Automation Magazine*, 10(2), 12-18.

Lammy, P., Brudermüller, M., Ferguson, M., Friis, L., Garmendia, C., & Gray, I. (2017). *LAB-FAB-APP Investing in the European Future we Want.* Available from: https://www.ecsite.eu/sites/default/files/labfab-app.pdf. [Last accessed on 2019 Apr 01].

Lavonen, P., Gedrovics, J., Byman, R., Meisalo, V., Juuti, K., & Uitto, A. (2008). Students' motivational orientations and career choice in science and technology: A comparative investigation in Finland and Latvia. *Journal of Baltic Science Education*, 2(86), 102.

Lund, H.H. (1999). AI in Children's Play with LEGO Robots. Palo Alto, California: *Proceedings of AAAI 1999 Spring Symposium Series*. p103.

Makarova, E., & Herzog, W. (2015). Trapped in the gender stereotype? The image of science among secondary school students and teachers. *Equality, Diversity and Inclusion*, 34(2), 106-123.

Maoldomhnaigh, M., & Hunt, A. (1988). Some factors affecting the image of the scientist drawn by older primary school pupils. *Research in Science and Technology Education*, 6, 159-166.

Mason, C., Butler-Kahle, J., & Gardner, A. (1991). Draw-a-scientist test: Implications. *School Science and Mathematics*, 91(5), 193-198.

Mataric, M. (2004). Robotics education for all ages. *Proceedings, AAAI Spring Symposium on Accessible,Hands-on AI and Robotics Education.* The Association for the Advancement of Artificial Intelligence. Available from: https://www.aaai.org/Papers/Symposia/Spring/2004/SS-04-01/SS04-01-004.pdf. [Last accessed on 2019 May 01].

Mead, M., & Metraux, R. (1957). Image of the scientist among high school students. *Science*, 126(3270), 384-390.

Medina-Jerez, R., Middleton, K., & Orihuela-Rabaza, W. (2011). Using the DAST-C to explore colombian and bolivian students' ımages of scientists. *International Journal of Science and Mathematics Education*, 9, 657-690.

Meyer, C., Guenther, L., & Joubert, M. (2019). The draw-a-scientist test in an African context: Comparing students' (stereotypical) images of scientists across university faculties. *Research in Science and Technological Education*, 37(1), 1-14.

Mikropoulos, T., & Bellou, I. (2013). Educational robotics as mindtools. *Themes in Science and Technology Education*, 6(1), 5-14.

Newton, L., & Newton, D. (1998). Primary children's conceptions of science and the scientist: İs the impact of a national curriculum breaking down the stereotype? *International Journal of Science Education*, 20(9), 1137-1149.

Ornstein, A. (2006). The frequency of hands-on experimentation and student attitudes toward science: A statistically significant relation. *Journal of Science Education and Technology*, 15(3-4), 285-297.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of*

Science Education, 25(9), 1049-1079.

PARSEL. (2009). *Popularity and Relevance in Science Education for Scientific Literacy*. Available from: http://www.icaseonline.net/parsel/www.parsel.uni-kiel.de/cms/indexe435.html?id=home. [Last accessed on 2020 Feb 03].

Pekdoğan, S., & Bozgün, K. (2019). I can draw a scientist whom ı ımagined. *Neuro Quantology*, 17(3), 1-8.

POLLEN. (2009). *POLLEN: Seed Cities for Science, a Community Approach for a Sustainable Growth of Science Education in Europe*. Available from: https://www.cordis.europa.eu/project/id/518399. [Last accessed on 2020 Jan 03].

PROFILES. (2014). *The PROFILES Project*. Available from: http://www.profiles-project.eu. [Last accessecd on 2020 Feb 03].

Resnick, M., Martin, F., Sargent, R., & Silverman, B. (1996). Programmable bricks: Toys to think with. *IBM Systems Journal*, 35(3-4), 443-452.

Rocard, M. (2007). *Science Education NOW: A Renewed Pedagogy for the Future of Europe.* European Commission. Brussels: Luxembourg: Office for Official Publications of the European Communities.

Rogers, J. (2010). *Under Represented Populations in Science and Technology: Robots for Science Education.* Available from: http://www.iguanarobotics.com. [Last accessed on 2020 Feb 03].

Sadi, Ö., & Cakiroglu, J. (2011). Effects of hands-on activity enriched ınstruction on students' achievement and attitudes towards science. *Journal of Baltic Science Education*, 10(2), 87-97.

Schibeci, R., & Sorensen, I. (1983). Elementary school children's perceptions of scientists. *School Science and Mathematics*, 83(1), 14-20.

Shih, B., Chen, T., Wang, S., & Chen, C. (2013). The exploration of applying lego nxt in the situated science and technology learning. *Journal of Baltic Science Education*, 12(1), 73-91.

Sipitakiat, A. (2000). *Digital Technology for Conviviality: Making the Most of Learners' Energy and Imagination*. Unpublished Master's Thesis, Massachusetts Institute of Technology.

Sotiriou, S., & Cherouvis, S. (2017). *Open Schooling Model, Deliverable D2.1, Open Schools for Open Societies Project.* Available from: https://www.openschools.eu/wp-content/uploads/2018/01/D2.1-Open-Schooling-Model.pdf. [Last accessed on 2020 Feb 03].

Stormont, D., & Chen, Y. (2005). Using mobile robots for controls and mechatronics education. *International Journal of Engineering Education*, 21(6), 1039-1042.

Thomas, J., Pedersen, J., & Finson, K. (2001). Validating the draw-a-science-teacher-test checklist: Exploring mental models and teacher beliefs. *Journal of Science Teacher Education*, 12(3), 295-310.

Tobin, K., & Fraser, B. (1987). *Exemplary Practice in Science and Mathematics Education.* Perth: Curtin University of Technology.