Ilkogretim Online - Elementary Education Online, 2020; 19 (3): pp. 1200-1213
http://ilkogretim-online.org.tr
doi:10.17051/ilkonline.2020.728020

The case of prospective teachers' integration of coding-robotics practices into science teaching with STEM approach

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Abstract. The aim of this study is to determine the level of integration of teacher candidates' acquisitions in course of "Coding and Robotics in Primary School" into the science teaching; and to explore teacher candidates' opinions on coding- robotics and the usage of them in lessons. For this purpose, a case study with 11 junior prospective primary school teachers was conducted in 2017-18 education year. After the participants took "Coding and robotics in primary school" at fall semester, they were asked to make STEM-based teaching by using robotic applications in the scope of the course of "Science and Technology Teaching II". Participants' teaching was rated with rubrics prepared by the researchers, and their lesson plans were analyzed through document analysis. Semi-structured interviews were also conducted to take the opinions of the participants on usage of robotics. The results showed that prospective teachers were mainly able to integrate robotics to the STEM-based science teaching. Additionally, prospective teachers suggested that robotics should be integrated to all courses, especially science, and that this would contribute to the problem solving and algorithmic thinking skills of the students.

Keywords: Science teaching, coding-robotic, STEM, teacher education

Received: 24.06.2019 Accepted: 02.01.2020 Published: 15.06.2020

INTRODUCTION

In 21st century, technology has made its usage necessary in many fields by developing rapidly. Today, technology is necessary for decent education to take place. The roles of technological developments that make daily life easier, are becoming more and more effective each day (Çömek & Avcı, 2016). Although there are many reasons for this situation, it can be said that the increase in the importance of globalization and global labor force necessitates the inclusion of technology in education (Sayın & Seferoğlu, 2016).

Lately, many countries, whether they are big, small, developed or developing, have been conducting studies on how to use technology effectively in their education systems (Sayın & Seferoğlu, 2016). These studies are mostly aimed at coding and robotics training. In recent years, the interest in robotics has increased rapidly and thus robotics has been accepted by many people as a means that has many great benefits in every stage of education (Johnson, 2003). Likewise, even though coding is a relatively new term, it has started to gain itself a place in preschool education and primary school education and has rapidly become a part of education.

Coding and robotics have been used in teaching different disciplines, especially science education and teaching different disciplines by converging them together as in STEM approach and they have started to be seen as an alternative education tool. The studies show that, because robotics help diminish the abstractness of mathematics and science (Nugent, Bradley, Grandgenett & Adamchuk, 2010) and create possibilities for real world practices of engineering and technology, they can be effective in STEM teaching (Nugent, Bradley, Grandgenett & Adamchuk, 2010). In addition, according to Chung, Cartwright and Cole (2014), robotics-based STEM teaching is more advantageous than traditional STEM teaching in terms of concretizing abstract concepts, unifying multiple disciplines, ensuring applied learning by connecting theory and practice and providing a fun and motivating learning environment.

This paper presented at World STEM Education Conference(WCES),8-10 June, İstanbul,Turkey. "Muşlu Kaygısız, G., Üzümcü, Ö., Uçar, F.M. (2018). Preservice Teachers' Level of Integrating the Knowledge of Robotic-Coding into Science Classes"

Thus, many studies have recently examined the different effects of robotic use in various courses on teachers, on prospective teachers or on students. For example, studies show that the use of robotics have positive impacts on mathematics performance of primary and middle school students (Lindh & Holgersson, 2007); science performance of primary (Karahoca, Karahoca & Uzunboylu, 2011) and middle school students as well as prospective teachers (Cuperman & Verner, 2013); engineering designing skills (Larkins, Moore, Rubbo & Covington, 2013) of middle school students and STEM knowledge (Barker, Grandgenett, Nugent & Adamchuk, 2010) of primary and middle school students. In addition, in a study examining the perceptions of teachers on the effects of robotics on students, teachers considered that robotics was an effective tool to prepare for the 21st century and for improving teamwork, communication skills, social skills, problem solving and critical thinking (Khanlari, 2013). Likewise, Kim, Kim, Yuan, Hill, Doshi and Thai (2015) have found that prospective teachers find the use of robotics suitable to increase the STEM participation. This study also revealed that the use of robotics increases affective participation like being interested and enjoying, and that there is an improvement in the lesson plans of prospective teachers for teaching STEM. Rrobotics activities are also found as effective in increasing self- efficacy in teaching science concepts (Jaipla-Jamani & Angeli, 2017) and encouraging computational thinking (Üzümcü, 2019). It is also stated that projects related to robotics improve the education quality in terms of teaching process (Tocháček, Lapeš & Fuglík, 2016). In addition, some studies in which Lego education sets are used as robotics activities show that Lego education sets positively affect the academic process skills of middle school students (Açıslı, 2017; Çavaş, Kesercioğlu, Holbrook, Rannikmae, Özdoğru & Gökler, 2012; Özdoğru, 2013); their academic creativeness (Çavaş et al., 2012); and their attitude towards science courses (Özdoğru, 2013).

As it can be understood from these studies, using rapidly developing technology of 21st century in education as well as in other parts of our lives and practicing interdisciplinary teaching enriched by technological developments (Zengin, 2016) have become a necessity in education rather than an alternative way to achieve goals. Therefore, it is of great importance for the teachers, who will be teaching at primary school level, to follow the developing technology, especially in the fields of coding and robotics, to receive the necessary training and to improve themselves. According to Çorlu, Capraro and Capraro (2014), to train the labor force that our country needs, it is not enough for the teachers to only be knowledgeable at the subjects that they master. It is stated that robotics can have different duties during the teaching process (Ospennikova, Ershov & Iljin, 2015), however it should be used as a learning tool because the important thing is integrating it within the curriculum (Alimisis, 2013; Altin & Pedaste, 2013). For this reason, the use of robotics in coding and robotics lesson in primary school is discussed in terms of its contribution to the learning processes.

Considering all of these, to raise a generation that can keep up with the globalizing world, it is significantly important for teachers and prospective teachers to receive training in robotics and coding, to use their knowledge and skills in this area affectively in an interdisciplinary way in courses and especially in science courses. However, the robotics studies aimed at prospective teachers are not enough, as most of the studies on coding and robotics are conducted on primary and middle school students (Yolcu & Demirer, 2017). For this reason, in this study, a special coding and robotics course was designed with a focus on prospective teachers and it was requested that prospective teachers use the acquisitions they gained from this course while teaching sciences with an interdisciplinary approach. Therefore, it can be said that this study is among the few studies in the field because it is aimed to determine the level of prospective teachers' use of coding and robotics in science courses and their views on this matter.

In line with this purpose, this study examines the case of how the prospective teachers integrated the acquisitions they gained from their third-year elective course: "Coding and Robotics in Primary School" into teaching sciences. Based on this purpose, the research questions of this study are as follows:

I. What are the prospective teachers' levels of integrating STEM-based robotic practices into science teaching?

II. What are the prospective teachers' views on the use of coding-robotic practices in the lessons?

METHODS

In this study, case study which is one of the qualitative research designs, has been conducted. Case studies can be defined as research made by deeply analyzing related cases, programmes and communities (McMillan, 1996; Büyüköztürk et al., 2016). Case studies are used in order to evaluate, define or explain the related case (Gall, Borg & Gall, 1996). In this study, holistic single case design, which is one of the case studies, has been used (Yıldırım & Şimşek, 2005).

This study aims to determine the case of prospective teachers' integrating the acquisitions gained from the course "Coding and Robotics in Primary School" into their teaching processes. Prospective teachers who complete the course "Coding and Robotics in Primary School" stated that they had problems using the thing they learned from that course, in classes. In addition, some prospective teachers stated that "the course is fun, but it is not that much related to the department". Thus, in order to detect how prospective teachers, integrate the knowledge they acquired form this course into the curriculum of primary school education, they were asked to plan and give a lesson within the context of "Science Teaching II" course, which they would take in the spring semester, using STEM-based robotic practices.

Study Group

The study group consists of 11 prospective teachers (7 women; 4 men) who are junior years in the department of primary school teaching at a private university in Gaziantep. The study group was chosen by purposive sampling method within the purpose of this study. The prospective teachers have no experience with robotics or coding before taking the course "Coding and Robotics in Primary School". The participants are aged between 20-21.

Practice

This study was carried out in 2017-2018 academic year. The prospective teachers took "Science and Technology Teaching I" course and "Coding and Robotics in Primary School" elective course in the fall semester and took "Science and Technology Teaching II" course in the spring semester. Within this study, the levels of prospective teachers in terms of integrating the acquisitions gained from the course "Coding and Robotics in Primary School" into their teaching processes have been examined. The syllabus of this course consists of computational thinking, programming, STEM and robotics. These subjects have been thought theoretically and practically by one of the authors through weekly 2-hour classes for 14 weeks, with an interdisciplinary approach and by relating the subjects to sciences and math courses. The course started with unplugged activities, continued with computer aided activities and ended with robotics activities. For robotic activities LEGO WeDo 2.0 set has been used because it is proper for primary school students. In the same semester, students in the study group took "Science and Technology Teaching I" course in the fall semester. Within this course, approaches in science teaching, learning environments used in science teaching, methods, techniques and strategies, misconceptions in science teaching, development of scientific process skills, and measurement and evaluation in science teaching were covered by one of the authors for 3 hours per week, through 14 weeks. In spring semester, within Science and Technology Teaching II course, the study group were asked to prepare a lesson plan based on the objectives they chose from the 3rd, 4th and 5th grades of Science Curriculum (2018) and give lessons by using the knowledge and skills they had acquired from the courses they took in the fall semester. While choosing objectives, they were asked to choose the ones that were both suitable for STEM and robotics. According to the acquisitions they chose, the prospective teachers prepared STEM-based robotics practices in groups of two with one of them being alone. The prospective teachers chose the subjects from the 3rd, 4th and 5th grade subjects so that subjects would be not repetitive while giving lessons. Considering the deficiencies of the prospective teachers regarding practice, activities in the level of this grade were accepted for the presentations.

Prospective teachers completed their robotics aided lessons in twenty minutes each. These lessons were given according to the order of the objectives in curriculum. Table. 1 shows the acquisitions that the prospective teachers chose in groups of two and one being alone. The prospective teachers gave their lessons in accordance with the related acquisitions and by using presentation and robotics set. The lessons were observed and evaluated by all of the authors.

Table.1 *Distribution of acquisitions chosen by prospective teachers for lessons in accordance with the groups.*

Group No	Curriculum Acquisitions	Summary of the Lesson Plan
Group 1	F.3.3.1. Observes the beings in motion and expresses the qualities of their motions. The qualities of the beings are qualified as accelerated, decelerated, rotating, swaying and changing directions.	By entering the class wearing a car costume, the concepts of acceleration, deceleration, rotation, swaying, direction change are shown. The students are reminded of the codes and their meanings. They are asked to write codes in accordance with the related concepts. The students are asked to prepare posters related to these concepts. They are asked to write codes for the parkour, prepared for the WeDo set. For example; “What should we do in the bumpy road in the parkour?” is asked. After they answer; “We should slow down”, the students are expected to write a code suitable for this motion. For the evaluation, Performance evaluation scale and structured grid are used.
Group 2	F.3.3.2.2. Defines the force by observing the effects of pushing and pulling forces on moving and stationary objects	By using suitable codes, the effects of pushing and pulling forces on moving and stationary objects are shown to the students on the robot made with WeDo sets. Cardboard codes are given to the students and they are asked to write codes in different ways. These codes are discussed. The class is divided into 2 groups. One group focuses on pushing forces and the other group on pulling force and they design a robot that would show the effects of these forces on moving and stationary objects. The robots designed are tested. The designs are discussed. In order to solve the problems that the students went through, an evaluation is made using an evaluation form.
Group 3	F.3.3.2.3. Discusses the dangers of moving objects in daily life.	By watching a video in which they can see the effects of moving objects, a discussion is made on what a moving object is, what it does and what its effects are. As a moving object, a car, made using the robotics set is shown. The students are asked to form a code that would move this car and are asked to operate it. At each try, they are asked to increase the engine power and to observe the impacts that it makes on the environment. By showing videos of floods, earthquakes and storms, a discussion is made on the damages they cause and how to prevent them. Observation rubric is used for the evaluation of the process; a test consisting of multiple-choice questions is used for general evaluation.
Group 4	F.5.6.3.1. Explains the destructive nature disasters caused by natural processes. Earthquakes, volcanic eruptions, floods, landslides, tornadoes and hurricanes are mentioned without going into detail.	Models of buildings and ground are prepared to show an earthquake. A concussion is created with WeDo to discuss the possible consequences for each floor and building. The students are asked to estimate the variables of the earthquake by preparing codes for different intensities and different durations and are asked to make observations by applying them. The students are divided into groups and asked to make durable and nondurable buildings using materials like pipes, wood, foam and cardboards. Then, they try out the buildings by using the robotics set. Assessment and evaluation are made with the predict-observation-explain method.

Table 1. *Continued*

Group 5	F.5.6.3.2. Expresses ways of protection from destructive natural disasters.	Disaster scenarios are created about floods, earthquakes and tornados. The students are asked to prepare a WeDo project in accordance with these scenarios. “Prevent Flooding” and “Drop and Rescue” projects for floods, “Robust Structures” project for earthquakes, and “Plants and Pollinators” and “Cooling Fan” projects for tornados are suggested. Questions like: How to move the set faster, how to increase durability with coding, are asked to the students and some changes are made on their codes in order for them to improve their projects. Projects are evaluated using robotics.
Group 6	F.4.3.1.1. Conducts experiments about how force facilitates the movement of objects and change their shapes.	The students are told that for a new designed car to start mass production in Turkey they have to pass the necessary tests and are asked to conduct semi-structured experiments by writing various codes suitable for the acceleration and the other motions of the car. The students are asked to create graphics and make necessary measurements by trying out the different designs of the students. The results of the different variables are discussed. Evaluation is made by using individual evaluation form, teamwork rubric and experiment control forms.

Data Collection Tools

In this study, data triangulation was used by observing and evaluating the lessons, examining the lesson plans, and conducting semi-structured interviews to increase the validity and reliability of the data.

Evaluating Lessons and Rubric

In order to evaluate the lessons of prospective teachers, researchers prepared a five-point Likert rubric based on the criteria determined by examining the relevant literature (Erman-Aslanoğlu & Kutlu, 2003; Genç, 2010; Kablan, 2012). In this process, expert opinion was sought to determine the suitability of the measurement tool and after that unsuitable items were removed or changed. The rubric is composed of a total of 35 items under 7 main headings, which are linking coding and robotics to the subject in accordance with the acquisition, field knowledge, planning of teaching and learning process, teaching process, classroom management, communication and evaluation of selected teaching material. The examples of the items under the main headings are as followed; item of “linking coding and robotics in accordance with the purpose” which is related to linking the subjects with robotics; item of “knowing basic terms and concepts about the subject” which is related to field knowledge; item of “determining methods and techniques in accordance with the acquisition” which is related to planning of teaching and learning processes; item of “linking the subject to daily life” which is related to teaching process; item of “ maintaining the interest and participation in the course” which is related to class management; item of “giving comprehensible instructions and explanations” which is related to communication; item of “being suitable for the purpose” which is related to the evaluation of the chosen material. The rubric was filled out independently by the authors during the lessons in order to determine the level of the lessons given by the prospective teachers. However, consistency was calculated in the evaluations made by two of the authors. Before the calculations, the opinions of the third author was sought in order to verify the data. The consistency of the authors was calculated with the reliability formula of Miles and Huberman (1994) and found to be .92. The scores of the prospective teachers were presented by calculating the absolute success percentage. While presenting the findings of the research, data on subjects such as communication, classroom management and field knowledge that are not within the scope of the research were not included in detail.

Analyzing Lesson Plans

In order to obtain data on some points which cannot be observed during the lessons, the lesson plans were examined. In order to evaluate prospective teachers' lesson plans, a different five-point Likert type rubric consisting of 15 items was prepared by the authors by considering some points not included in the rubric used for observation on evaluating lessons. In addition, one question was left open ended in order to determine the assessment and evaluation methods of the prospective teachers. Lesson plans were evaluated independently by two of the authors. Consistency percentage of the two authors was calculated as .89. The third author was excluded from this evaluation in order to verify the results. After the independent evaluations, the third author also participated in the evaluation. The consistency percentage of the third author and the other two authors was calculated as .87. While evaluating the lesson plans, data related to the following points were tried to be obtained: Whether the students produced a new product or not; Whether comprehensible instructions were given to the students or not; The suitability of the products expected from the students to their levels and to STEM approach; The contribution of the products to the learning of the subjects, their accuracy in terms of robotics and coding; Whether the plans were suitable for the curriculum objective or not and how the assessment and evaluation will be made.

Semi Structured Interviews

Semi-structured interviews were conducted with 10 of the 11 students who participated in the research in order to obtain detailed information about the use of robotics and coding in the lessons. These interviews included topics such as the benefits of using coding and robotics, their relevance to other courses and the STEM approach, and their contribution to science teaching. The audio recordings of the interviews were first transcribed and then coded by two authors. In the coding, consistency percentage was calculated as .88.

Data Analysis

During the observation and evaluation of the lessons, rubric was used. The scores obtained from rubric were calculated as absolute percentage points. Evaluation of the lesson plans was done by document analysis and scored via another rubric. The data obtained from semi-structured interviews were obtained by inductive content analysis and open coding.

RESULTS

Findings Regarding to The Levels of Prospective Teachers to Integrate STEM-Based Robotic Practices into Science Courses.

Sample lesson plans and lectures prepared by prospective teachers have been evaluated to determine their levels of integration of STEM-based robotic practices into science courses. One of these evaluations is made by the observation of lectures and the other one is by document analysis of the lesson plans.

Lectures of prospective teachers in Science Teaching II course were evaluated by using rubric. The absolute evaluation percentages of the six groups according to the evaluation criteria for the lectures are given in Table .2. The detailed findings that are not related to the purpose of this study are not included.

Table 2. *Absolute value percentages of the lectures of prospective teachers*

Headings	1st group	2nd group	3rd group	4th group	5th group	6th group	Mean
Association with robotics and coding	83	93	83	100	100	97	93
Field Knowledge	83	80	90	93	93	83	87
Planning of the Teaching-Learning Process	73	85	70	95	93	86	84
Teaching Process	74	82	76	96	98	74	83
Classroom Management	68	86	66	94	94	82	82
Communication	70	80	63	87	87	70	76
STEM-based Robotic Practice	80	98	94	100	100	100	95

* The score calculation for each title is made out of 100.

The absolute value percentages in Table 2 shows that prospective teachers have the highest scores in association with robotic-coding and STEM-based robotics practice.

According to this, it was determined that the prospective teachers integrate science courses with robotic-coding in accordance with its purpose and that they provide students with lessons, including STEM-based fields, that will cater for cooperative learning and problem solving. This finding is supported with the data acquired from the lesson plans of the students. For example, below, there is a citation from one of the prospective teachers regarding cooperative learning and problem solving:

"Group Activities: Then the members of the group write down what is written on the board on their activity sheet. After each group writes down the notes suitable for their subjects, they are asked to prepare a WeDo project that is suitable for the problem in the given scenario. The students choose the most suitable one after analyzing WeDo projects. While analyzing they write down the parts that they want to change. The students are given project design sheet. They are asked to design the projects in accordance with the steps in this sheet and they are told that the evaluation will be made on filling the blanks and the benefits of the end-product. After finishing the project, the students present it using the coding given in WeDo." *Group-5*

"Elaboration: The students are then asked a few questions and the projects are improved by changing the coding.

For floods;

1. Flood Prevention: How to make the barrier more durable? How to move faster during a flood and how can the increase of the durability is ensured by coding? How can this project be implemented for wider rivers?

2. Drop and Rescue: How to increase the amount of load carried by the rope? How to fasten the movements of a rope that carries more loads?" *Group-5*

The sample lesson plan of the fifth group shows that prospective teachers plan their lessons in a way that would ensure cooperative learning and problem solving. In addition, it also shows that prospective teachers give information regarding how the students will be evaluated in their lesson plans and they plan the assessment and evaluation processes.

Aside from these, as table 2 shows, STEM-based robotic practice is designed in an original, purpose-oriented way and is in accordance with the design principles. This finding shows that the acquisitions of robotic practices that were prepared after the analysis of the lesson plans of the prospective teachers can be learned. As to give an example, below, there is an exact citation from one of the lesson plans.

"The teacher operates the robot with suitable codes to observe the effects of push-pull powers that the teacher made with WeDo sets on mobile and still objects. At the same time s/he gives information about the subject. The students are asked to write down their observations and inferences.*"* *Group-2*

The quotation of the second group above illustrates the robotics practice that was used in the lesson planned to teach the acquisition of the curriculum: "defines the force by observing the effects of pushing and pulling forces on moving and stationary objects". As the example citation shows, robotic practice is oriented towards making students learn the acquisitions. In addition, the compliance of design principles with the lesson plans are examined in more detail and it was found that they corresponded with the evaluations during the presentations. The findings regarding this are included in the following pages again.

Results related to the scores of the prospective teachers show that the ones who are successful in subject matter knowledge are better at teaching-learning process. The points obtained during the lesson planning and teaching-learning process are close to each other. The field with the lowest mean scores is communication. It was observed that the candidates who had planned clear and regular explanations about the instructions in the lesson plans had difficulty in designing practices according to these instructions. In addition, the analysis of the lesson plans prepared by the prospective teachers shows that they plan the lectures in accordance with the level of the students and that the activities are aimed at producing interesting and new products. Prospective teachers plan the projects that would enable designing projects with which students can present their own unique products and test different situations by changing the variables. Below are citations from the plans designed by the prospective teachers.

"Robust Structures; How to increase the durability of a building? Build a building from Legos. Test the buildings, whose durability have been increased, by increasing and decreasing the magnitude of earthquake. Build a nondurable and a durable building and time their crashing period." Group-4

Quotations show that prospective teachers made plans for students that would enable activities aimed at creating different designs that include STEM. With these designs, students will be able to develop the necessary knowledge and skills for acquisition and will be able to carry out STEM-based learning through robotics and coding. In all of the plans, prospective teachers included practices where students could make their own original designs. In addition, the three plans included practices where students can test some points by changing variables before the designing process. In this way, students would be able to develop some of their knowledge and skills prior to their design, through the design of prospective teachers and they will have a chance to see some examples.

Lastly, it has been shown that most of the prospective teachers can implement the evaluation stage in their lesson plans accordingly, during their lessons. It has also been seen that the evaluation tools of the prospective teachers vary according to the purpose of the subject, the method they use and the student level. For example, prospective teachers in the fifth group used the analytic project evaluation rubric which they developed for project evaluation and asked the students to write a reflection paper for self-evaluation.

Findings Related to Prospective Teachers' Opinions About the Use of Coding and Robotics Practices

At the end of the semester, semi-structured interviews were conducted with the prospective teachers in the framework of three basic questions. These questions are: "What do you think about coding and robotics?", "In which courses do you think the robotics can be used?" and "what do you think about STEM practices in science lessons by using robotic-coding?". In the first question, codes were presented fewer than two themes in line with the answers of the prospective teachers, while the codes obtained from the other questions were given directly.

Prospective teachers were first asked a question to learn their views on robotic-coding. The findings regarding the answers of the candidates are included in Table 3. While answering the questions, prospective teachers gave answers based on their own acquisitions from time to time. For this reason, the opinions of students about their ideas about the course are sometimes included in the codes.

Theme 1: Affective Benefit: The interviews made with prospective teachers show that they find robotic-coding affectively beneficial in many ways. Those robotic-coding practices are fun, interesting and game like are positive points indicated by prospective teachers. The fact that it is suitable for this age and it improves imagination is some of the points that are beneficial for children. The following are citations from interviews with prospective teachers.

"... actually it (robotics) taught me how to teach in a different way. It enables children to have fun. Students don't understand and get bored in fields like sciences; it concretizes these fields and makes it easier for the students to understand by turning into a game-like situation and it makes the students apply these into their daily lives. It facilitates my work and helps both the kids and me..." *Prospective teacher 2*

In addition, the prospective teachers stated it is an advantage that it enables collaborative work. The views of prospective teachers on robotics and coding are mostly positive. Only a few of the prospective teachers said that it is a disadvantage that the planning process is tiresome.

Table 3. *Themes and codes regarding robotic-coding*

Theme	Code	Frequency
Affective Benefit	Fun	8
	Interesting	8
	Enhancing imagination	5
	Making learning enjoyable	5
	Cooperation	5
	Being up-to-date	4
	Game-like nature	3
Cognitive Benefit	Facilitate STEM	9
	Integration to daily life	9
	Interdisciplinary nature	8
	Problem-solving skill	7
	Making concretization	6
	Algorithmic thinking	6
	Gaining different perspectives	6
	Providing permanent learning	5
	Multi-faceted thinking	4
	Academic development	3
	Better sense-making	3
	Recognizing details	2

Theme 2: Cognitive Benefit: The prospective teachers stated that robotics coding has some advantages in terms of enabling STEM and being interdisciplinary. The STEM approach basically involves interdisciplinary work. However, prospective teachers generally mention being STEM-based and being interdisciplinary differently because they plan STEM based robotic practices. Prospective teachers also consider it important to develop different perspectives and integrate them into daily life. Problem solving ability is another important point when it comes to teaching abilities. This ability is followed by "concretization, algorithmic thinking". While "permanent learning, realistic" codes are obtained that support concretization; "multiple thinking, awareness of details" codes supporting algorithmic thinking were also obtained under this theme. Below are citations from the interviews with prospective teachers.

"... I can integrate it into my daily life, I have started to think mathematically, I have been thinking about how an elevator works, how a tea pot works. I have broadened my field of thinking or rather I have learned how to use it. It can be associated with all kinds of fields. It improves children's imagination. It is interesting, for example computer software is interesting to me now. It is fun… I have improved academically." *Prospective teacher 7*

"...it changes the perspectives of primary school students on problems, makes them think that it does not only have one solution, there are more than one ways to achieve a goal. It can also be integrated into other courses; we can integrate few courses and can teach many subjects in one course. This enables permanence and interpretation. It can operate with and without STEM (it can be planned). Children concretize some things and learn by realizing the details".

Prospective teacher 5

As it is seen in the citations, prospective teachers think that robotic-coding can have different cognitive benefits.

The second question directed to prospective teachers is to explore their opinions about the courses which robotic-coding can be used in. Table 4 includes the findings regarding the answers of the prospective teachers.

Table 4. *Codes and frequencies related to the courses where robotics can be used in courses*

	Code	Frequency
Courses in which robotics can be used	Science	8
	Mathematics	8
	All courses	4
	Social Sciences	3
	Turkish	3
	Advantages of Primary School Teaching	3
	Geography	1

According to Table 4, science is the most recommended course that robotics can be used in and it is followed by mathematics. The fact that the prospective teachers stated that robotics can be used in verbal courses shows that they realized that robotic-coding can be used not only in sciences or math but also in social sciences. In addition, they stated that, the fact that primary school teachers master in different branches makes it easier to integrate robotics into other courses.

Lastly, prospective teachers were asked about their opinions on STEM practices developed by using robotic-coding in science courses. Table 5 includes the findings regarding the answers of the prospective teachers.

While all of the prospective teachers stated that the STEM practices supported by robotics were appropriate in science courses, almost all of the prospective teachers stated that the most appropriate course was science. They stated that these practices mostly contributed to the improvement of creativity. In addition, the prospective teachers who stated that they provided the opportunity of applied learning, expressed that creativity and imagination can also develop because they provide new experiences while practicing. They also stated that they would be of interest to the students, that they would help students to learn willingly and that they would provide the opportunity for students and teachers to work interdisciplinary. These findings support the answers to the first interview question.

In the semi-structured interviews, some prospective teachers also made suggestions for the use of robotic-coding. One of these suggestions is to open a “robotics club” for prospective teachers and elementary school students in order to develop their robotics skills continuously within more flexible time period. Another suggestion is making “robotics and coding in primary school” course a compulsory one in related programs. Suggesting that this course should be compulsory rather than an elective also shows that prospective teachers care about robotics and coding.

Table 5. *Opinions on STEM practice developed by using robotic-coding in science courses*

	Code	Frequency
Opinions on STEM Practice Developed by Using Robotic-coding in Science Courses	Improving creativity	8
	Suitableness of the science course	8
	Possibility of applied learning	6
	Improving imagination	5
	Possibility of interdisciplinary study	5
	Catching the attention of the student	4
	Learning willingly	4
	Involving technology	4
	Dynamic structure	2
	Enabling gradual improvement	1

DISCUSSION and CONCLUSIONS

This study analyzes how prospective teachers use the acquisitions they gained from "Coding and Robotics in Primary School" course in "Science and Technology Teaching II" course. Discussion and conclusion regarding the findings of this research are below.

The results obtained from the observations of the lessons and analysis of lesson plans showed that prospective teachers were able to integrate STEM-based robotics into the science course at a very high level. Accordingly, the prospective teachers were found to be successful in integrating knowledge and skills they acquired in robotics into preparing lesson plans and also into giving lessons according to the plans they prepared. The fact that prospective teachers were able to use robotics in science courses with an interdisciplinary approach, in accordance with the subject, acquisition and level of the curriculum, showed that their elective course "Coding and Robotics in Primary School" was thought in accordance with the objectives and it was beneficial for prospective teachers. This finding was also supported by interviews with prospective teachers. While prospective teachers stated that the course is beneficial for their academic development, also, moving from their own acquisitions, they think that they will be able to make the students gain both cognitive and emotional competence. Therefore, all of the prospective teachers stated that robotic-coding should be used in all courses, especially in science courses, and that every primary school teacher candidate should take a course about coding and robotics in order for this to happen. Similar findings were found in another study examining the effects of integrating robotics into the undergraduate program (Maxwell & Meeden, 2000). In another study conducted with teachers and prospective teachers who do not have robotic experience, it was found that when suitable conditions were provided for STEM teaching, participants could program robots, have fun while learning STEM and apply STEM in their own classes in the most appropriate way (Ortiz, Bos & Smith, 2015). This finding coincides with the findings of this study, in that, prospective teachers could successfully integrate STEM-based robotic practices into the science course and define this process as fun and beneficial.

In addition, the observations during the lectures showed that prospective teachers received the lowest scores from the communication. The possible reason for this is that even though the prospective teachers gave the lessons on an elementary school level, these lectures were given within "Science and Technology Teaching II" course which they took in their undergraduate education and for this reason the audience of the prospective teachers consisted of other prospective teachers who also took this course but did not take "Coding and Robotics in

Primary School" elective course. Therefore, the robotics-related guidelines that the candidates in the study group gave, were not exactly understood by the other candidates. This can also have been affected by the fact that prospective teachers were new to giving lessons that are suitable for the syllabus, acquisition oriented, and in which they used suitable strategies, methods and techniques. Taking all of these into consideration, it can be thought that prospective teachers partially have problem in expressing themselves.

In the semi-structured interviews made with the prospective teacher they stated that they found "Coding and Robotics in Primary School" course fun and interesting and that it improves imagination. In the interviews in which the concept of learning while having fun was emphasized, robotics was likened to games. This study did not directly use gamification, however; another study showed that it is effective in motivating students throughout their learning process and drawing their attention (Küçük & Şişman, 2017). For this reason, it can be said that robotics is interesting and motivating.

In addition, interviews show that prospective teachers found it useful to integrate STEM-supported robotic practices into science courses because it enables applied learning. There are also studies in the literature regarding the presence of active learning and practical teaching in STEM teaching, which may be of interest and provide an appropriate learning environment (Christensen, Knezek & Tyler-Wood, 2015; Kim, Kim, Yuan, Hill, Doshi & Thai, 2015). Therefore, it can be said that using robotics for teaching STEM is common (Altin & Pedaste, 2013; Ortiz, Bos & Smith, 2015; Yolcu & Demirer, 2017).

Prospective teachers named science course as the most suitable course to use robotics in. The reasons for this are that science course is "too abstract for students" and that "it is hard for students to understand". Some studies found that robotics is beneficial in explaining abstract and unclear science subjects (Miglino, Lund & Cardaci, 1999; Erdoğan, Çorlu & Capraro, 2013). Another study stated that one of areas of usage of robotics is teaching (Ospennikova et. al, 2015). Therefore, it can be said that robotics is a teaching tool that facilitates concretization.

Moreover, the fact that the study group consists of prospective primary school teachers enabled the participants to evaluate different branch courses at the same time. This is related to the disciplined structure of primary school teaching. For this reason, they stated that they could integrate robotics into mathematics, Turkish, social sciences and other branch courses, especially science course, and expressed this multidisciplinary structure with practices. The studies (Lindh & Holgersson, 2007; Sullivan, 2008; Benitti, 2012) show that robotics is mostly integrated into programming, science and math courses. The fact that prospective teachers stated that they can use robotics in different branches and interdisciplinary practices, show that prospective teachers gained a new modernist perspective.

In addition to this, in the interviews, prospective teachers stated that the use of robotic-coding could contribute to thinking and collaborative working skills of students such as problem solving, algorithmic thinking, multiple thinking, and awareness of details. Because robotics involves programming, it is directly related to algorithms. Given the fact that the main purpose of the algorithms is problem solving, it confirms the views of the prospective teachers. The studies (Benitti, 2012; Khanlari, 2013; Bers, Flannery, Kazakoff & Sullivan, 2014; Jaipal-Jamani & Angeli, 2017; Yolcu & Demirer, 2017) also show that robotics help improve those skills. Therefore, it can be said that the thoughts of the prospective teachers regarding the benefits of using robotics were right.

In conclusion, the use of robotics from an early age in the context of STEM is important in meeting the skilled future workforce of countries (Sullivan & Bers, 2016). Therefore, prospective primary school teachers should receive relevant trainings in robotics and coding and be able to integrate them into their courses. In this context, it can be said that for prospective teachers especially prospective primary school teachers to be trained in new educational fields like robotics and to use robotics in interdisciplinary fields like STEM will be beneficial for the improvement of skills like problem solving.

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