# Views of Pre-service Teachers in Different Disciplines about Coding with Arduino

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## ABSTRACT

When the needs of present and future life are examined, 21st-century skills are gaining importance day by day. There are various teaching methods, techniques and aids that support the development of individual skills and characteristics. Coding has also taken its place among these methods and techniques and continues to gain popularity with increasing speed. In this study, the aim was to create a learning environment where pre-service teachers can experience coding practices. In this context, the study aimed to determine the views of pre-service teachers about their experiences regarding Arduino implementations. In line with this purpose, a workshop was designed where Arduino implementations with the mBlock platform included 30 students studying in the department of computer and instructional technologies, science education department and mathematics education department. This study consists of qualitative data in the form of the case study. Research data was collected with a semi-structured interview form that included four open-ended questions. The final form was obtained by receiving expert opinions about the questions. During the interview process, each participant was informed about the interview's purpose and confidentiality and registration permission was obtained. The content analysis method was used in the data analysis process. The research results were discussed in light of the literature and suggestions were made based on the experiences gained for future researchers.

**Keywords:** *Coding, Arduino, mBlock, teacher training*

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## INTRODUCTION

Being able to keep up with the ever-changing world has become a necessity. One of the sources of this change is technology. With the rapid development of technology, teaching has focused on the universal principles of science that will form the basis of future solutions (Gingl, Makan, Mellar, Vadai, & Mingesz, 2019). Different structures and innovations are required for meaningful and permanent learning in education systems (Butuner, 2019). Many countries use technology effectively in educational environments (Sayın & Seferoğlu, 2016). Technology, which is widespread in all areas of our lives, creates a coding gap that can't be filled by existing educational practices (Siegle, 2017). Countries such as Austria, Bulgaria, Czech Republic, Denmark, Estonia, France, Hungary, Ireland, Israel, Lithuania, Malta, Spain, Poland, Portugal, Slovakia and the United Kingdom have officially integrated coding into their curricula at regional and local levels (Balanskat & Engelhardt, 2015). In light of the importance of thinking skills, the value of coding that addresses the postmodern period's needs is increasing day by day in educational environments.

Coding offers unique opportunities to engage students in multidisciplinary learning (Oh & Lawson, 2020). Coding practices are vital for students with technology experience when the problem solving behind these practices is considered (Wang, 2017). Coding is accepted as an essential skill for graduates to be successful in their future professional or academic careers (Nguyen, 1998). The school curriculum promises to prepare students for the future beyond learning just coding (Popat & Starkey, 2019). Teaching students how to code is considered to be one of the most important keys for future professions, and students' ability to adapt to learning outcomes and their computational skills in higher education can be increased with coding (Mayer, 2013; Meeker, 2014; Smith, Sutcliffe, & Sandvik, 2014). The important thing here is to acquire algorithm logic before coding education, not codes or coding language (Hasan, Kanbul, & Ozdamli, 2018). Coding education is expected to enable students to understand and solve problems through their imagination and creativity (Highfield, 2014; Kafai & Burke, 2014).

With the use of block-based tools in the coding process, the difficulties encountered in the process are eased (Karaahmetoglu & Korkmaz, 2019). These coding tools are very common, cheap and useful tools that are actively used for educational purposes and to teach modern technology, coding, and experimentation in different disciplines at various levels (Gingl et al., 2019). One of the most widely used of these tools is mBlock, which is a Scratch-based development program that enables coding for Arduino projects (Basarmak & Hamutoglu, 2019). Using MBlock coding software and mBot robot kits, the basic skills and concepts of coding can be explained and tested easily and quickly (Şahin & Korkmaz, 2020). Mblock is a platform that can code with the drag-and-drop method and convert code blocks into C ++ language without writing any code. The code blocks created afterwards are loaded into the Arduino microprocessor and run independently from the computer environment and direct robotic devices' operations (Sahin, 2018). Arduino, which is an open-source kit, is designed as a controller that regulates the working process of electronic circuits (Darmawan, Ratnadewi, Sartika, Pasaribu, & Arlando 2017). By working in a product-oriented way with programming, individuals can carry out collaborative solution development activities for a problem is encountered in daily life. These possibilities make physical programming with Arduino an important part of STEM education (Sarı & Yazıcı, 2020).

There is a need for people who know how to apply and teach coding skills in different disciplines to solve problems in various fields (Royal, 2017). Different strategies are needed to solve interdisciplinary problems and for students to gain knowledge and skills. For this, STEM education is accepted as an assistive tool (Lacey & Wright, 2009). STEM teaching facilitates understanding, development and use of students' knowledge in various implementations of science, technology, engineering and mathematics (Sarı & Yazıcı, 2020). Although the in-class implementation methods of STEM education have some differences, STEM is mainly based on an interdisciplinary approach, followed by a process in which gains from multiple disciplines are presented together (Tunc & Bagceci, 2021).

Along with these changes in curricula, students recently met concepts such as STEM, arduino, coding, robotics, etc. (Akkaş Baysal, January, & January, 2020). In addition to this, coding has always been one of the basic and compulsory modules in computer education. This module has deep links with programming, mathematics, science, design and technology, and offers insight into both natural and artificial systems (Nguyen, 1998). From this point of view, coding is considered important as it brings together all areas of STEM. This situation improves STEM skills and adds fun and creativity to the environment (Zainal et al., 2018). Besides, regardless of the language used, programming can also provide logical thinking skills, creating algorithms, problem solving, and even analytical thinking for learners (Pala & Mıhcı-Türker, 2019).

Today, both public and private schools carried out studies about coding implementations, and this situation has popularised rapidly. For this reason, the proficiency expectations of institutions, parents and students from their teachers in this field are also intensifying. Although the education faculty students who are the teachers of the future are willing to learn and experience coding, there are no compulsory or elective courses about coding practices within the curriculum published by the Council of Higher Education for education faculties. This is a crucial issue for pre-service teachers to experience coding practices before their professional lives. In this context, in this study, the aim was to examine the views of pre-service computer and instructional technologies teachers, pre-service science teachers and pre-service mathematics teachers about experiences during coding practice with Arduino.

## RESEARCH METHOD

### Research Model

This study was designed based on qualitative research patterns. According to Denzin and Lincoln (2000), qualitative research is an established activity that positions the observer in the world, and this design includes an interpretive, naturalist approach to the world. Researchers state that the world is transformed into a series of representations through various implementations such as field notes, interviews, photographs, recordings and notes. In this study, a case study, which is one of the qualitative research types, was used. Within the scope of case studies, there is an in-depth investigation of a specific system that has certain boundaries involving an activity, individuals, process or event (Creswell, 2016).

### Participants

This study was carried out with 30 students studying in the computer and instructional technologies department, science education department and mathematics education department in the education faculty of a public university. Each of the departments as mentioned above were entitled to a quota of 10 participants. The first ten pre-service teachers who voluntarily applied to their departments were included in the study group.

**Table 1.** *Demographic characteristics of participants*

| | | | Department | | | Total |
|---|---|---|---|---|---|---|
| | | | Computer and Instructional Technologies | Science Education | Mathematics Education | |
| Gender | Female | n | 6 | 7 | 8 | 21 |
| | Male | n | 4 | 3 | 2 | 9 |

### Data Collection Tool

The data for this study was collected with a semi-structured interview form. This form was prepared in line with the views of three field experts. The final form included three open-ended questions and a sentence completion involving a metaphorical approach. Open-ended questions on the form were as follows: (1) How would you explain the changes that the project caused in you?, (2) Can you explain the positive and negative experiences you had during the project? (3) What are your criticisms and suggestions regarding the project?. For the metaphorical approach, sentence completion of "Coding is like …… because……" was used.

### Implementation Process

The aim was to create a learning environment where pre-service teachers can experience coding practice in this study. The implementation was completed within the scope of two-hour sessions per week during 8 weeks. In this process, students were enabled to work collaboratively in groups. Ten groups comprising three participants in each of the groups were determined. Each group consisted of students studying in the three different departments of computer and instructional technology department (ICT), science education departments (SE) and mathematics education (ME) department. The purpose of designing groups in this way was to create an interdisciplinary working environment. Block-based coding and algorithm logic were introduced to the students during the implementation process. At this point, the mBlock platform and Arduino were used. Within the study's scope, the reason for choosing the mBlock platform is that it is a free program and its user-friendly interface and ease of use. During the extracurricular implementation process, the necessary Arduino sets were distributed to the groups depending on the activity content.

**Table 2.** *Content of the implementation program based on coding with Arduino*

| Week | Content |
|---|---|
| 1 | Introduction of Arduino and Mblock<br>Basic electronics concepts<br>Implementations of Tinkercad and Fritzing |
| 2 | Lighting a Led<br>Traffic signals<br>Use of potentiometer<br>Lighting a colourful RGB Led |
| 3 | Lighting a bulb in the dark<br>Parking sensor with Led and Buzzer<br>Writing on LCD display |
| 4 | Thermometer, Digital meter, DC motor usage, Servo motor control |
| 5 | Motion detection, Protractor making, Motion radar |
| 6 | Obstacle avoiding car, smart waste bin |
| 7 | Learner robot arm |
| 8 | 3D printer usage |

**Data Analysis**

The content analysis method was used to analyze qualitative data. Content analysis is defined as a process that summarizes and reports on data written within the scope of basic content and messages (Cohen, Manion, & Morrison, 2007). The steps followed in the analysis process are as follows: (1) Coding of data, (2) Finding categories, (3) Organizing the obtained codes and categories, and (4) Interpreting the findings (Creswell, 2016; Yıldırım & Şimşek, 2011).

Participant names were coded in order to protect the privacy of the participants. The abbreviation used at this point was $P_nG_n$DG in which group, department and gender are specified. Explanations regarding the abbreviations are as follows: $P_n$: Pre-service teacher number in the project; $G_n$: Group Number; M: Mathematics Education Department; C: Computer and instructional technologies department; S: Science Education Department; F: Female Participant; M: Male Participant. For example, $P_3G_1$MF-coded participant is a female pre-service teacher in the 1st group studying in the mathematics education department.

**Validity and Credibility**

The strategies of “credibility”, “transferability”, “consistency” and “verifiability” are used to ensure validity and reliability for studies conducted in qualitative dimensions. However, since the issue of reliability which is valid for quantitative research is not relevant for qualitative research, “consistency” and “repeatability” conflict with the basic features of qualitative research (Creswell, 2016; Yıldırım & Şimşek, 2011). Therefore, some precautions were taken to ensure validity and reliability in this study.

The reliability of qualitative data was evaluated with the Miles and Huberman formula (Miles & Huberman, 1994). In the analysis process, which was conducted based on the content analysis method, it is important to investigate the similarity of the obtained data coded by different experts. Miles and Huberman (1994) explained this similarity as internal consistency, which describes the consensus between experts in their model. This similarity is calculated with the use of the formula: $\Delta = C \div (C + \partial) \times 100$ ($\Delta$: Reliability coefficient, $C$: Number of subjects/terms agreed upon, $\partial$: number of subjects/terms on which there is no consensus). Internal consistency calculated according to consensus between experts who analyse data should be at least 80%. In this study, qualitative data derived from the interviews were investigated by three experts. Internal consistency was calculated as 0.92.

Being in the implementation environment helps the researcher to control his prejudices (Başkale, 2016). During the data collection process, 30 pre-service teachers and all researchers participated in the practice and continuous interaction was ensured with each participant. Besides, observation notes were created with other researchers for data triangulation during the implementation process, laboratory camera recordings were used and interviews were conducted with pre-service teachers. The study group was determined voluntarily from pre-service teachers who wanted to receive robotic coding training. In order to describe the participant characteristics and the implementation environment in advance, it was important that the participants were receiving education in the 3rd year of their departments of computer and instructional technologies education, science education and mathematics education and that they were students who had taken different courses given by the researchers in the education faculty.

## FINDINGS

The views of the pre-service teachers about the implementation are analyzed and presented in this section. The descriptive analysis results regarding the participant profile included in the study are shown in Table 3.

**Table 3.** *Profiles of participants*

| | | | Department | | | |
|---|---|---|---|---|---|---|
| | | | Computer and Instructional Technologies | Science Education | Mathematics Education | Total |
| Interest in computers | Yes | n | 8 | 4 | 4 | 16 |
| | | % | 26.7 | 13.3 | 13,3 | 53.3 |
| | No | n | 0 | 3 | 3 | 6 |
| | | % | 0.0 | 10.0 | 10,0 | 20.0 |
| | Partly | n | 2 | 3 | 3 | 8 |
| | | % | 6.7 | 10.0 | 10,0 | 26.7 |
| Interest in coding | Yes | n | 6 | 8 | 4 | 18 |
| | | % | 20.0 | 26.7 | 13,3 | 60.0 |
| | No | n | 0 | 1 | 2 | 3 |
| | | % | 0.0 | 3.3 | 6,7 | 10.0 |
| | Partly | n | 4 | 1 | 4 | 9 |
| | | % | 13.3 | 3.3 | 13,3 | 30.0 |
| Having coding training | Yes | n | 1 | 1 | 5 | 7 |
| | | % | 3.3 | 3.3 | 16,7 | 23.3 |
| | No | n | 9 | 9 | 5 | 23 |
| | | % | 30.0 | 30.0 | 16,7 | 76.7 |
| Total | Yes | n | 10 | 10 | 10 | 300 |
| | No | % | 33.3 | 33.3 | 33,3 | 100 |

When Table 3 is examined, 70% of the pre-service teachers participating in the project voluntarily were female and 30% were male participants. In this study in which ten pre-service teachers from the three departments participated, the participants who were most interested in computers were the students (n = 8) studying in the ICT department. It was also determined that students studying in SE showed most interest in coding. Another remarkable finding in the table is that the participants who have previously received training in robotic coding consisted of students studying mathematics with the highest percentage. These findings showed that in this interdisciplinary study, students from each department participated in the implementation with different references, expectations and backgrounds. In other words, pre-service teachers who participated in the same project from three different disciplines brought their differences into the teaching and practice environment.

In this section, content analysis results regarding open-ended questions and metaphorical sentence completion in the interview form are presented. After completing the implementation, two categories termed as personal development and plans were obtained within the framework of the responses of the pre-service teachers regarding the changes that occurred. These categories and their codes are presented in the following table.

**Table 4.** *Pre-service teacher outcomes from the coding process*

| Categories | Codes | n | Examples of Participants |
|---|---|---|---|
| Personal development | Learned coding | 27 | $P_1G_1SF$, $P_6G_2MF$, $P_{11}G_4CM$, $P_{24}G_8MF$, $P_{18}G_6MF$ |
| | Learned the basis of robot design | 23 | $P_7G_3SM$, $P_{20}G_7CM$, $P_{10}G_4SF$, $P_{12}G_4MF$, $P_{22}G_8SF$ |
| | Development of computer skills | 12 | $P_{15}G_5MM$, $P_9G_3MF$, $P_{17}G_6CM$, $P_{13}G_5SF$, $P_{15}G_5MM$ |
| | Spent free time productively | 7 | $P_{25}G_9SF$, $P_{26}G_9CF$ |
| Future plans | Design a robot | 14 | $P_7G_3SM$, $P_{20}G_7CM$, $P_{10}G_4SF$, $P_{11}G_4CM$, $P_{12}G_4MF$, $P_{22}G_8SF$, $P_{25}G_9SF$ |
| | Be beneficial for future students | 10 | $P_{27}G_9MF$, $P_{28}G_{10}SF$, $P_{29}G_{10}CF$ |
| | Attend various trainings | 9 | $P_{16}G_6SM$, $P_9G_3MF$, $P_1G_1SF$, $P_8G_3CF$ |
| | Take part in robot competitions | 6 | $P_{26}G_9CF$, $P_{27}G_9MF$, $P_{28}G_{10}SF$, $P_{29}G_{10}CF$, $P_{30}G_{10}MF$ |
| | Make useful inventions for the country | 2 | $P_3G_1MF$, $P_7G_3SM$ |
| | Represent my country abroad | 1 | $P_{27}G_9MF$ |

Within the framework of personal development, 27 participants emphasized that they learned coding, while 23 participants also stated that it was the basis for robotic coding. In addition to this, 12 participants emphasized the changes in their computer skills development. In this context, most pre-service teachers' perceptions of their development regarding coding and based on the design process are remarkable findings. When the category of future plans was investigated, 14 pre-service teachers reported their desire to design robots and 10 participants planned to be beneficial to their students through these technologies in their future professional lives. However, 6 pre-service teachers expressed their willingness to participate in various robot competitions.

Samples of participant responses to the first question are provided below:

$P_9G_3MF$: “I didn't know anything about coding. I learned many things in this project.”

$P_{18}G_6MF$: “I learned new things about circuit elements and coding.”

$P_{14}G_5CF$: “I want to write the code without any support and apply what we learned in the lesson.”

$P_{25}G_9SF$: “I would like to be able to build the robot that I designed myself in the future.”

$P_{27}G_9MF$: “I learned a lot. Robotic coding, Arduino and many more. These were things I had never known before.”

In Table 5, pre-service teachers explain their experiences regarding the coding process with content analysis results for the second interview question. Answers to this question are grouped under two categories as positive experience and negative experience.

While 23 of the participants stated that the coding process was enjoyable for them, 22 pre-service teachers identified that the project was instructive. Twenty-one participants also determined that they used time for a useful purpose. In addition to these, most emphasized positive experiences regarding the project process, though negative participant views were also determined. At this point, the most common answer ($n = 17$) was that the project duration is long. Seven pre-service teachers underlined that the process was tiring. While the project was too long for participants who had coding experience before and pre-service teachers from the ICT department, the students who experienced coding for the first time stated that the process was effective and adequate.

**Table 5.** *Pre-service teacher experiences during the coding process*

| Categories | Codes | n | Examples of Participants |
|---|---|---|---|
| Positive Experience | Funny | 23 | $P_{13}G_5SF$, $P_7G_3SM$, $P_{19}G_7SM$, $P_{28}G_{10}SF$ |
| | Getting new information | 22 | $P_{17}G_6CM$, $P_{14}G_5CF$, |
| | Use of time in a useful way | 21 | $P_{15}G_5MM$ |
| | Showing development according to the field of interest | 17 | $P_1G_1SF$, $P_{12}G_4MF$ |
| | Getting new ideas | 16 | $P_{24}G_8MF$, $P_{15}G_5MM$ |
| | Satisfying my curiosity | 14 | $P_{13}G_5SF$ |
| | Collaboration with friends from different departments | 14 | $P_{15}G_5MM$, $P_3G_1MF$, |
| | Eye-opening | 12 | $P_{13}G_5SF$ |
| | Exciting | 10 | $P_{24}G_8MF$ |
| | A good start to coding | 8 | $P_{15}G_5MM$ |
| | Socializing | 6 | $P_{10}G_4SF$, $P_{14}G_5CF$ |
| | Overcoming fears about coding | 17 | $P_{30}G_{10}MF$, $P_9G_3MF$, $P_3G_1MF$, $P_{23}G_8CM$ |
| Negative Experience | Long application process | 17 | $P_{30}G_{10}MF$, $P_9G_3MF$, $P_3G_1MF$, $P_{23}G_8CM$ |
| | Tiring | 7 | $P_{27}G_9MF$, $P_5G_2CF$, $P_{18}G_6MF$ |
| | Waste of time | 6 | $P_{23}G_8CM$, $P_3G_1MF$, $P_2G_1CF$ |
| | Willingness to work only with their own department mates | 5 | $P_{30}G_{10}MF$, $P_9G_3MF$, $P_3G_1MF$, $P_{23}G_8CM$, $P_{30}G_{10}MF$, $P_{20}G_7CM$ |
| | Coding is not like my dream | 3 | $P_{12}G_4MF$, $P_{16}G_6SM$ |

$P_{13}G_5SF$: “It's a very interesting project for me. I applied because I was very curious and wanted to learn, I wanted to participate. I had fun, there were things I learned during the project. There were also things I was curious about. Then I did research because I wanted to do something by myself. I watched videos on Youtube, tried to do new things with my Arduino account by myself, so I was glad. I had no trouble, no problem.”

$P_{28}G_{10}SF$: “One of the most important features is that I have never seen such work in a place like this before. So I haven't had a chance to participate before. So I think the project was fun and successful as far as I observed, because I think it's a different project, because it was a project that developed creativity and would apply to STEM education.”

$P_{19}G_7SM$: “This course... For example, we worked with ultrasonic sensors. You understand the logic behind the work there. It was beeping more frequently between 10 cm and 20 cm. Between 20 cm and 30 cm, it beeped a little less often. You know, I was seeing and associating it with computer distances. I think it was nice from this aspect.”

$P_{15}G_5MM$: “This project will be an advantage for my future career...”

$P_{25}G_9SF$: “It was an experience for my profession that I would start 1-0 ahead. Thank you.”

$P_1G_1SF$: “I am always open to students' ideas. I will always go after these ideas because so many students in our country want to produce new ideas and projects. But many of them, unfortunately, cannot be discovered. In this sense, I would like to develop these students in the future with what I learned in this project.”

The codes in the two categories termed criticism and suggestions regarding the project are presented in the following table.

**Table 6.** *Pre-service teachers' criticisms and suggestions about the coding process*

| Categories | Codes | n | Examples of Participants |
|---|---|---|---|
| Criticism | Difficulties in working and acquiring materials outside of the course | 11 | $P_{17}G_6CM$, $P_{14}G_5CF$, $P_{12}G_4MF$ |
| | Being out of class in the evening | 7 | $P_5G_2CF$, $P_{18}G_6MF$ |
| | Mixed groups | 5 | $P_{30}G_{10}MF$, $P_9G_3MF$, $P_3G_1MF$, $P_{23}G_8CM$, $P_{30}G_{10}MF$ |
| | Time consuming | 3 | $P_2G_1CF$ |
| Suggestion | Other classes should also take this course | 26 | $P_{13}G_5SF$, $P_7G_3SM$, $P_{19}G_7SM$ |
| | Course hours should be short | 17 | $P_{24}G_8MF$, $P_3G_1MF$, |
| | It should be an elective course | 14 | $P_{28}G_{10}SF$, $P_7G_3SM$, $P_{19}G_7SM$ |
| | Leaving the laboratory open | 10 | $P_1G_1SM$, $P_{12}G_4MF$, $P_{17}G_6CM$, $P_{14}G_5CM$, |
| | It should be a compulsory course | 9 | $P_{13}G_5SF$, $P_7G_3SM$, $P_{19}G_7SM$ |
| | Each department should take a separate course | 5 | $P_1G_1SF$, $P_{26}G_9CF$ |

The pre-service ICT teachers and participants who previously experienced robotic coding expressed their willingness to complete the course faster and in a shorter time, to reduce the weekly course hours, and to work with homogeneous groups consisting of participants from the same department instead of mixed groups. This is because pre-service ICT teachers and participants with robotic coding experience stated that they had to lead other participants in their groups during the implementation process. On the other hand, pre-service SE teachers determined that coding should be included in the curriculum as an elective course or a compulsory course. In addition, while pre-service science teachers agreed that faculty of education students should receive coding training, pre-service mathematics teachers agreed on a shorter duration of the implementation process and the availability of the laboratory whenever they want. The pre-service teachers also mostly expressed their satisfaction about the abundance of material, practicing for as long as they want, interacting with their group friends and doing the coding activities comfortably.

$P_{19}G_7SM$: “My favorite point may be that there were Arduino cards, enough for everyone, and the number of groups was small, everyone was taken care of individually. That is, there was no shortage in terms of material. So what I like most is that everyone has materials, so if we are going to teach coding then we will give materials to everyone.”

$P_{28}G_{10}SF$: “Absolutely, the material was abundant, time is exactly the same. There was no problem. If I do not have a teacher, I do not think that otherwise students will learn. Everyone has to have their stuff. Fortunately, there was. Everyone will touch these materials.”

$P_4G_2SF$: “Everyone will touch it, install it on their computer. Our course was too long, but in some places, it was just a show on weekends. We worked until we got tired.”

$P_{25}G_9SF$: “Everything was fine. ……. Because we have seen coding steps and materials. We are graduating, it was very good that we learned them. I hope the friends who will come after us will benefit from it in a better way.”

Categories termed activity, concept, and operation were formed within the framework of the pre-service teachers' metaphors. The content analysis results regarding the metaphoric sentence completion related to coding are presented in the following table. Pre-service teachers were asked to complete the sentence "Coding is like …… because……" and to form their own metaphors. Themes and codes created by examining the answers through the content analysis method are shown in Table 7.

**Table 7.** *Pre-service teacher metaphors about their coding experiences*

| Categories | Codes | n | Examples of Participants |
|---|---|---|---|
| Activity | Cooking | 6 | $P_{25}G_9SF$, $P_{28}G1_0SF$ |
| | Computer programming | 4 | $P_5G_2CF$, $P_{10}G_4SF$ |
| | Amusement park | 4 | $P_{17}G_6CM$, $P_1G_1SF$, $P_{18}G_6MF$, $P_{19}G_7SM$ |
| | Helping | 2 | $P_{26}G_9CF$, $P_9G_3MF$ |
| | Cycling | 1 | $P_7G_3SM$ |
| | Horror tunnel | 1 | $P_{16}G_6SM$ |
| Concept | Mathematics | 2 | $P_5G_2CF$, $P_{15}G_5MM$ |
| | Science fiction | 2 | $P_3G_1MF$, $P_{21}G_7MM$ |
| | Philosophical trend | 1 | $P_{23}G_8CM$ |
| | World Order | 1 | $P_{20}G_7CM$ |
| Function | Cell | 3 | $P_{22}G_8SF$ |
| | Technology | 3 | $P_{13}G_5SF$, $P_{14}G_5CF$ |
| | Factory | 2 | $P_{30}G_{10}MF$ |
| | Crossword | 1 | $P_{24}G_8MF$ |
| | Chain | 1 | $P_{12}G_4MF$ |
| | Court | 1 | $P_9G_3MF$ |
| | Metabolism | 1 | $P_{22}G_8SF$ |
| | Electronic | 1 | $P_{29}G_{10}CF$ |
| | A mysterious house | 1 | $P_4G_2SF$ |

While male pre-service teachers mainly created metaphors based on global concepts, female participants' operation and verb metaphors are remarkable. The highest number of metaphors were collected under the theme termed as activity. Themes named function and concept follow this theme. The pre-service teachers mainly compared the coding process to a positive activity (n = 17) such as making a cake and going to the amusement park. However, there was also a metaphor of a negative activity (n = 1) such as a fear tunnel. In addition, participant responses (n = 14) focusing on the functioning of structures such as cells, technology and factories constitute the theme termed as function. Metaphors (n = 6) created within the framework of concepts such as mathematics and science fiction are included in the theme named concept. Examples of metaphors are presented below.

$P_4G_2SF$: “It's like a mysterious house. Because there are so many things we can do with coding.”

$P_7G_3SM$: “It's like riding a bike. Because it requires gradual learning, and ultimately achieving it.”

$P_{16}G_6SM$: “It is like a great torment. Because the result will not be as planned.”

$P_{20}G_7CM$: “It is like a world order. Because robots will exist in the future”

$P_{21}G_7MM$: “It's like science fiction. Because it starts with a dream.”

$P_{12}G_4MF$: “It's like a chain. Because if you make a mistake in the steps, the system won't work.”

$P_{15}G_5MM$: “It's similar to math. Because if you do different things, you get the same results.”

$P_{22}G_8SF$: “It is similar to a cell. Because a large structure is formed by the union of small cells, and the structure may malfunction with a missing cell.”

$P_{23}G_8CM$: “It's like the philosophical trend. Because the more you think, the more you start to design.”

$P_{24}G_8MF$: “It's like a puzzle. Because it's complex and fun.”

$P_{25}G_9SF$: “It's like making a cake. Because you design it by yourself.”

$P_{26}G_9CF$: “It's like helping. Because helping people make their lives easier.”

## DISCUSSION AND CONCLUSION

When it comes to the 21st century with the developing technology, access to information has become easier and the age of information has emerged. Today's world expects individuals to be producers. For individuals to display their productivity, it is necessary to implement new and different programs that encourage them to question, think and be creative (Akgündüz et al., 2015). The education system is expected to transform in this way (Çakıroğlu, 2016).

When changes in the pre-service teachers were examined due to the project they participated in, two categories termed as personal development and future plans were obtained. Within the scope of personal development, most pre-service teachers stated that they learned coding procedures and the underlying logic and gained knowledge about the basis of a robot design process. When future plans are examined, pre-service teachers' most common view is answers about designing a robot. They also stated their wishes to be beneficial to their students in their future professional life. The Partnership for 21st Century Learning (P21, 2020) explains the qualities that individuals are expected to have in the future within the framework of 21st century skills. When the relevant literature is examined, robotic implementations support several qualities in this framework which are defined as critical thinking (Özel, 2018), communication (Eguchi, 2014; Khanlari, 2013; Sklar, Eguchi, & Johnson, 2003), collaboration (Eguchi, 2014; Khanlari, 2013; Verner & Ahlgren, 2004) and creativity (Khanlari, 2013; Martin, 2001). From this point of view, this finding explaining pre-service teachers' future plans is thought to be remarkable. Indeed, one of the most important goals of the designed implementation process is to draw attention to the importance of coding and robotic applications and to raise awareness about value of these practices for cultivating individuals who can meet the needs of the future. At this point, it is thought that the project process led to positive tendencies about the stated goal. Also, the pre-service teachers desire to participate in various robotics competitions organized throughout the country are interpreted as an indication of their willingness to improve themselves in this field.

When pre-service teachers' views about their experiences in the project were examined, two categories called positive experience and negative experience were obtained. Under the category called positive experience, most of the pre-service teachers described the coding process as fun. In addition to this, there were pre-service teachers who described the implementation process as exciting. Stating these positive tendencies towards the process constituted the idea that pre-service teachers' interest in this field was triggered. Participant views that they gained new information within the scope of the project and that they were enabled to spend their time in a useful way are evaluated as showing that the implementation process was productive. In this context, the designed project content achieved its goal. Reporting positive views towards working groups designed as an interdisciplinary working environment is interpreted as a remarkable and important finding. Fourteen participants identified that working with pre-service teachers from different departments during this process was eye-opening and 8 participants determined that the working environment allowed them to socialize. Considering the importance of interdisciplinary study approach and cooperation, the development of pre-service teachers in these two areas was supported by the project. In addition, the presence of pre-service teachers who overcame their fear of coding with the process can be interpreted as a finding that negative tendencies can be changed with these implementation processes. In fact, when the relevant literature is examined, pedagogical beliefs about instructional technologies are one of the key concepts in teachers' use of technology in the classroom (Ertmer & Ottenbreit-Leftwich, 2010). This change is thought to be achieved with experience, which is described as a very important factor in overcoming this situation (Ertmer, 1999; Ertmer & Ottenbreit-Leftwich, 2010; Ottenbreit-Leftwich, 2007).

When the category called negative experience was examined, most pre-service teachers evaluated the implementation process, which was completed in 8 weeks, as long. Based on this finding, it is suggested that the process designed within the scope of two-hour sessions per week could be planned as two sessions per week. On the other hand, while some pre-service teachers evaluated the project process as a "waste of time", some pre-service teachers determined that their desire to develop more creative projects did not materialize in this process. The desire of some participants to work only with their friends from their departments, instead of an interdisciplinary working environment, is evaluated as a remarkable finding.

The pre-service teachers' evaluations about the coding process were shaped within two categories termed criticism and suggestions. The most common answer in the criticism category was that they could not find the opportunity to work outside of the implementation since they didn't have their own Arduino sets. Also, 3 pre-service teachers stated that these applications were time consuming. When the category of suggestions was examined, most of the pre-service teachers expressed the view that the application process should be experienced by all students studying in the faculty of education. Pre-service teachers also identified that coding should be included in the curriculum as an elective course, while others stated that this subject should be among the compulsory courses. Within the scope of efforts to revise the curricula of teacher education institutions, itself as a global issue (Tomte, Enochsson, Buskqvist, & Karstein, 2015), there is an approach that provides the students in these institutions with the opportunity to experience technology firsthand and integrates technology into the whole curriculum (Tondeur et al., 2012). In addition, the suggestion about establishing a study group with colleagues in the department instead of the interdisciplinary study groups was previously expressed in the criticism category and in the negative experience category.

When pre-service teachers' metaphorical perceptions about coding were examined, 3 categories were obtained as activity, concept, and function. The participants generated 6 metaphors in the "activity" category, 4 metaphors in the "concept" category and 9 metaphors in the "function" category. Most of the pre-service teachers had metaphorical perceptions of "cooking" in the activity category and show their views that the cooking process has an algorithmic structure. In addition, metaphorical perceptions such as "mathematics" and "science fiction" were determined in the concept category which can be associated with the cognitive structure in the coding process. Finally, pre-service teachers' evaluations with metaphorical perceptions such as "cell", "technology" and "puzzle", which are within the scope of the function category, can be associated with the idea that coding is a complex problem that needs to be solved. Metaphors offer different reflections than the current concept (Thayer-Bacon, 2003). Metaphorical perceptions are the beginning of a cognitive process for individuals and enable them to perceive the world means a way of thinking and seeing (Aladağ & Kuzgun, 2015). Metaphor is the core of human thought and is particularly important for connecting bodily experience to abstract structures (Francis & Davis, 2020). When the metaphorical concepts used in similar studies about coding are analysed, the study which was conducted by Fanny, Julie and Anne-Sophie (2020) entitled "Developing a Critical Robot Literacy for Young People from Conceptual Metaphors Analysis" aimed to identify the conceptual metaphors, especially the structural and spatial metaphors, used in the language of children and teachers, and to analyse the role of these metaphors in these situations. In this study, trainers used metaphors to help children understand computer components. For example, researchers determined trainers used the metaphor of "deliverer who fetches information from the hard drive and brings it to the processor" to clarify the operation of random-access memory. Also, to make robots concrete and manipulable, the trainers used the bee to create a metaphor within the context of their instructions. On the other hand, students sometimes questioned the components using the metaphors which the trainers presented. For example, they asked about RAM using the "bus" metaphor. At this point, they asked the question "bus, but if she doesn't have a wheel, how will she move?". Also, the study conducted by Fidan, Debbag and Cukurbasi (2021) aimed to reveal pre-service teachers' perceptions about concepts such as LEGO robotic teaching implementations, augmented reality and flipped classroom through metaphors. According to the results of this research, 15 different metaphors related to the concept of LEGO robotic teaching implementations were categorized as 'educational-entertainment tool', 'technological tool' and 'development tool', while 24 different metaphors related to the concept of augmented reality were created. In other research designed by Çalisici and Sümen (2018), pre-service teachers' perceptions of science, technology, engineering and mathematics (STEM) education approaches were examined through metaphors. In a public university in Turkey, pre-service teachers from different grade levels were trained in STEM education to determine their perceptions. The pre-service teachers were asked to write a metaphor for STEM education on the form containing the expression "STEM Education (Science-Technology-Engineering-Mathematics) ... Because ...". As a result of the research, valid metaphors formed by pre-service teachers regarding STEM education were collected under 9 different conceptual categories developed based on common features. According to these categories, pre-service teachers stated that they see STEM as complementary disciplines, useful, necessary, involving different disciplines, highly liked, unnecessary, constantly developing, requiring solid substructure and work, and an individual-specific approach.

**Suggestions**

Pre-service teachers can improve themselves individually to more advanced levels by participating in Ardunio implementations carried out with different disciplines during the implementation process. In this process, they can benefit from Massive Open Online Course environments such as Cousera, EdX and Udemy and transfer the implementations which they learn to their students with block-based activities from simple to complex. Pre-service teachers with this perspective should be encouraged to work in interdisciplinary environments. It may be suggested that researchers plan the study group to bring together participants from different disciplines in their studies about coding and STEM. In addition, within the scope of the implementation process, it is suggested that the participants actively carry out studies including coding practice.

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