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Investigation of STEM Approach Applications Based on Model Eliciting Activities in Primary School 4th Grade Mathematics Lessons of Pre-Service Classroom Teachers

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Abstract

In this research, it is aimed to examine how the pre-service classroom teachers apply the STEM approach applications based on model eliciting activities that they designed themselves in primary school 4th grade mathematics course. In the research, the basic qualitative research design was used. The research was carried out in a public primary school in a province in the Aegean region within the scope of Teaching Practice I course in the fall semester of the 2019-2020 academic year. 4 of the 8 participants took part in the research as event practitioners and the other 4 as observers. Practitioner participants designed and implemented 3 STEM approach applications based on model eliciting activities implementation plans. At the end of each activity, semi-structured interviews were held with the practitioners, and when all the activities were finished, with the observer participants, and written opinions of 4th grade primary school students were obtained through structured forms. As a result of the analysis of the observations and interviews, it is seen that the participants completed the STEM approach applications based on model eliciting activities in 6 stages, each stage has a flexible structure that can be switched between each other, they have the motivation to implement the activities despite their lack of experience, and in general, each participant completes the process. When only the opinions of the participants was analyzed, it was concluded that despite the difficulties they experienced, they were willing to apply the STEM approach based on model eliciting activities in their professional lives, and that the students' interest and motivation towards the applications increased, and that, apart from some other skills, students gained cooperation, communication, creativity, and critical thinking skills.

Keywords: STEM approach applications based on model eliciting activities, prospective classroom teacher, STEM education approach

Introduction

Education is a dynamic field that is influenced by many different sectors. One of the sectors where education is affected is the financial sector. As a result of the economic competition between countries in the globalizing world, the concern of the United States of America (USA) to lose its leadership position in economic and political areas began to emerge in the late 20th century. With these concerns, the STEM (Science, Technology, Engineering and Mathematics) education approach has emerged in order to meet the labor force they need and has led an increasing number of countries to review or change their education systems and curricula in recent years (Gencer, Doğan, Bilen and Can, 2019). STEM (Bybee, 2010), which origins date back to the 1990s, was founded in 2001 by Judith A. It was put forward by Ramaley as an educational term or concept (Yıldırım and Altun, 2015). In general terms, STEM education can be defined as the process of obtaining a technological product by supporting the theoretical knowledge of science and mathematics with the engineering application dimension (Thomas, 2014). According to another definition, STEM education is an approach that includes at least two STEM components, provides solutions to students' daily life problems, and utilizes the technology and engineering design process in this process (Aydın-Günbatar and Tabar, 2019).

Research has shown that integrating mathematics and science makes learning more connected and relevant, and has a positive impact on students' attitudes and interests towards school, their motivation to learn, and their achievement (Stohlmann, 2013a). In today's world, where multidisciplinary approaches and skills are required to solve increasingly complex problems, the school curriculum, which includes STEM activities integrated with the preservation of the integrity of the relevant disciplines and the equipping of teachers with the necessary

knowledge, commitment and resources, seems to be a positive step forward in education (English, 2017). As a result of the meta-analysis of the studies in which the STEM education approach was applied, it was concluded that STEM education programs contributed positively to the mathematics success of the students and this contribution was statistically significant (Siregar, Rosli, Maat, & Capraro, 2019). However, although it is widely accepted that mathematics supports all other STEM disciplines, there is clear evidence that it plays an underestimated role in integrated STEM education (Maass, Geiger, Ariza, & Goos, 2019). Engineering education should not be allowed to cause mathematics to remain in the background by being carried out predominantly based on the science curriculum (English, 2015).

Including the STEM education approach in the curriculum seems to be a need to climb the steps in the educational race, and mathematical modeling is recommended as a tool to make the transition to STEM education. Teachers, as the main actors in the implementation of new approaches, should adopt the relevant approaches and be equipped with the necessary knowledge and skills at this point (Doğan, Gürbüz, Çavuş Erdem and Şahin, 2018). In addition, Erbaş et al. (2014) stated that there are insufficient resources for teachers who want to integrate modeling into teaching processes, therefore, more research is needed on the use of modeling for different education levels. They added that with the studies to be carried out, it can be ensured that the resources that can be used in pre-service and in-service teacher training programs are produced and that there is a need for resources that include good examples of modeling tasks for teachers.

The potential contribution of mathematical modeling to STEM education should not be overlooked and academic studies should be conducted on the potential to be used together with the common aspects of mathematical modeling and STEM education (Aydın and Derin, 2018). Kertil and Gürel (2016) state that mathematical modeling is included in all STEM-related applications to some extent. In other words, not all STEM activities are modeling activities, but students can experience the mathematical modeling process in many STEM activities. Teachers can design integrated STEM activities that focus on mathematics discipline using mathematical modeling (Yabas, Boyacı, & Çorlu, 2020). Mathematical modeling can be used both to fulfill STEM tasks such as problem solving and collaborative work that students will face in future societies and to implement education for sustainable development. Since mathematical modeling is based on real-world situations, it can be said that the use of mathematical modeling for STEM task is compatible with the use of education for sustainable development (Suh and Han, 2019).

Maass, Geiger, Ariza and Goos (2019) suggest that mathematical modeling should be included in the school curriculum in a meaningful way as one of the methods they propose to increase the role of mathematics in STEM activities. "Modeling activities", one of the application methods of mathematical modeling, have emerged as an alternative to the use of STEM education in mathematics lessons. However, modeling activities alone may not be sufficient for the realization of engineering skills and interdisciplinary learning. Similarly, Lesh (2010) stated that modeling activities are activities that aim to complete the content of a course rather than being a complete curriculum. When the STEM education literature is examined, it is possible to see the importance of mathematical modeling, but there is also a limited number of studies on the nature of modeling as a bridge between STEM disciplines (Hallström and Schönborn, 2019). In addition,

based on the study they stated that there was no change in mathematical thinking and problem solving skills in primary school mathematics teacher candidates after STEM activities where modeling activities were not used (Yıldırım and Sidekli, 2018). It can be thought that seeing the results of modeling activities as a result of using the STEM approach in mathematics-based applications may contribute to the literature.

Stohlmann, Moore and Cramer (2013) state that in many modeling activities, students use their mathematical ideas with activities established in the context of science to make sense of the tasks given by a real customer. In this study, it is aimed to design modeling activities based on the realistic modeling approach to be applied in a way that will include the achievements of 4th grade primary school mathematics and science course. Model eliciting Activities and Engineering Design Process stages were integrated in order to use the STEM education approach in primary school mathematics courses. The constructed structure is called the STEM approach applications based on model eliciting activities. Mathematics must be used as a foundation in the activity planned. For this purpose, the course should start with modeling activities involving mathematics course achievements, and be aimed creating a mathematical model for solving real-life problems, including science course achievements, by applying engineering design process and producing a three-dimensional product by associating the created mathematical model with science achievements. The stages of the STEM approach applications based on model eliciting activities implementation process created by the researcher are given in Figure 1.

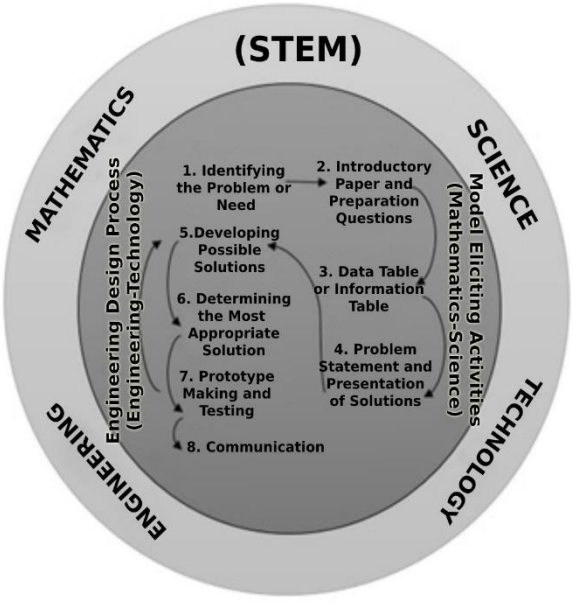

Figure 1. Implementation Process of the STEM approach applications based on model eliciting activities

As a result of the literature review, it seems possible to say that modeling activities are a method that can be used to apply the STEM education approach in the context of mathematics. In this context, this study aims to investigate the applicability of the STEM approach based on modeling activities at primary school level. The researches conducted in the field of teacher candidates' education for STEM approach in Turkey are of the application type and include

theoretical knowledge and activities related to STEM and approximately half of them have been carried out in the last 3 years. In these studies, the samples are mostly science teachers (Gül and Taşar, 2020). As a matter of fact, considering the studies conducted, the use of the STEM education approach at the primary school level and the lack of applications in the sample of classroom teacher candidates are striking, based on the achievements and subjects of mathematics lessons. In addition, considering the researches that mathematical modeling can be a method in the mathematics-based application of STEM education approach, there is a lack of research in this field in Turkey. In this context, this study aims to examine how the classroom teacher candidates perform the applications in the 4th grade mathematics course of primary school and the opinions of the classroom teacher candidates and primary school students regarding the use of the applications by observing the video recordings of the STEM approach applications based on model eliciting activities that are applied by the prospective classroom teachers in a public school in the classroom environment. It is thought that the research will eliminate the deficiency mentioned in the literature and will answer the following problems.

- What are the stages that the participants use in the process of STEM approach applications based on modeling activities?
- What are the views of the participants on the STEM approach applications based on model eliciting activities process?
- What are the opinions of the participants about the next activity and professional life at the end of the STEM approach application process based on modeling activities?
- What are the opinions of the participants regarding the effect of STEM approach practices based on modeling activities on the skill development of primary school students?

Method

The Method of the Study

In the research, "basic qualitative research" design, which is one of the qualitative research methods, was used. In basic qualitative research, researchers are interested in how people interpret their lives, how they build their own worlds, and what the meanings they add to their experiences are. The main goal is to understand how people understand their lives and experiences. Basic qualitative research may be the most common type used in education. Data are collected by observation, interview or document analysis. Data analysis is performed to determine repetitive patterns. The themes obtained from the resulting data constitute the findings (Merriam, 2013). In the research, qualitative data were collected through observation and interviews and the research was conducted based on the qualitative research paradigm. Other qualitative research patterns were not expressed as a method because data was gathered from an intervened and purposefully modified environment rather than revealing the existing situation. In such cases, the basic qualitative research design, which is generally used as a research design in the literature, was preferred as a method. In this context, in this research, the basic qualitative research design was used to reveal the application process of prospective classroom teachers for the application of the modeling activities-based STEM approach in the 4th grade mathematics course of primary school, to reveal and interpret the meanings they add to their experiences.

The Source of the Data

The maximum diversity among the purposeful sampling methods of the teacher candidates selected to carry out the process in the research was determined according to the sample selection. In the selection of the maximum diversity sample, a small sample is studied in order to represent the diversity of individuals at the maximum level. The aim is to reveal the points where individuals with diversity are similar or different (Gezer, 2021). Before the implementation phase, prospective primary school teachers were given training to design activities in accordance with the STEM approach application process based on modeling activities within the scope of the Mathematics Teaching II course while studying in the third grade in the spring semester of the 2018-2019 academic year. According to the scores they received from the activities they designed at the end of the training, eight teacher candidates were selected on a voluntary basis among the teacher candidates who received the highest (85 points and above), the lowest (50 to 64 points) and the average score (65 to 84 points). Accordingly, two candidates were determined among the teacher candidates with the highest score, two candidates were determined among the teacher candidates with the lowest score, and four candidates were determined among the teacher candidates with the average score. The sample selection over the score was made only for the purpose of increasing diversity, it was not used as a variable in any way during the research process. Six of the selected study group are female and two are male. Among these eight teacher candidates, one of the highest, one of the lowest, and two average scoring teacher candidates designed an activity suitable for the STEM approach application process based on modeling activities and applied it to 4th grade students studying in a public primary school within the scope of the Teaching Practice I course. The other four teacher candidates participated in the lessons in observer status.

Data Collection Tools

In this study, observation and interview techniques were used to collect data. The researcher observed classroom video recordings in order to examine the activity application processes of prospective classroom teachers. During the observation process, the activity application process was carried out by taking notes and examining the teacher-student dialogues and teacher-student behaviors in the classroom. Therefore, no observation form was used. The data obtained as a result of the examinations made according to unstructured observation were also analyzed in accordance with the opinions of the participants about the application process. In addition, a semi-structured interview form was prepared to determine the opinions of the prospective classroom teachers and it was used to interview the prospective classroom teachers after each of the three activities. In addition, a different semi-structured interview form was prepared and applied to determine the views of the prospective classroom teachers based on their observations at the end of the process. The interview information obtained from the participants is presented in Tables 1 and 2, followed by the interview questions.

Table 1. *Schedule of interviews with classroom teacher candidates performing the application*

No	Code name	Meeting Date	Date of second meeting	Date of third interview	Interview location	Total duration of three interviews
1	Serkan	31.10.2019	28.11.2019	16.12.2019	Office	1 h. 2 min 45 sec
2	Reyhan	31.10.2019	28.11.2019	13.12.2019	Office	58 min. 34 sec.
3	Doruk	31.10.2019	28.11.2019	13.12.2019	Office	1 h. 23 min. 57 sec.
4	Yağmur	31.10.2019	28.11.2019	16.12.2019	Office	1 h. 8 min 27 sec.
Total duration						4 h 33 min 43 sec.

Table 2. *Schedule of interviews with classroom teacher candidates observing the application*

No	Code name	Date of discussion	Interview location	Duration of meeting
1	Zehra	17.12.2019	Office	11 min 48 sec.
2	Bilge	17.12.2019	Office	20 min. 17 sec.
3	Selin	18.12.2019	Office	07 min. 18 sec.
4	Nalan	18.12.2019	Office	21 min. 02 sec.
Total duration				1 h. 1 min. 25 sec.

Semi-structured interview questions with prospective practitioners:

1. What are your views on the implementation of the STEM approach based on model eliciting activities at primary school level? Do you find it applicable?

• Physical structure of schools,

• Primary school level, children's level,

• Current curriculum status,

• In terms of socio-economic level.

2. What is the effect of the activity you designed and implemented on your thoughts on the use of STEM approach applications based on modeling activities in mathematics class?

3. What do you think about the effect of the activity you designed and applied on your mathematics teaching skills?

4. What do you think about the teaching of mathematics by associating it with other disciplines? what is the contribution of STEM approach applications based on model eliciting activities to this situation?

5. What are the situations that you have difficulty in the activity you design and implement, and what are the difficulties you encounter?

• Planning (designing).

• Implementation (teaching process).

• Measurement and evaluation dimensions.

6. What solutions have you developed for the situations you have difficulty in the activity you designed and implemented?

• Planning (designing).

• Implementation (teaching process).

• Measurement and evaluation dimensions.

7. What elements do you think facilitate the activity you design and implement?

• Classroom teacher, student level, physical structure of the classroom, suitability of the subject, etc.

8. What do you think about the impact of the first activity you designed and implemented on the design and implementation experiences of your second activity?

9. What do you think about the effects of the experiences you have gained from the activity you designed and implemented when planning the next STEM approach application based on model eliciting activities?

10. Do you drop the STEM approach based on modeling activities in your professional life?

• If you are thinking, why do you apply it?

• In which courses do you apply it?

11. Do you have any other thoughts you would like to add?

Semi-structured interview questions with observer teacher candidates:

1. Would you consider the process in general? Can you convey your experiences and observations?

2. Do you think that the teacher candidate you observe can fully design and implement activities?

• What do you think are the good and bad aspects?

• What would have been more feasible?

3. What do you think about the benefits of the activities implemented to children?

4. What are your views on the implementation of the STEM approach based on model eliciting activities at primary school level? Do you find it applicable?

• Physical structure of schools

• Primary school level children's level

• Current curriculum status

• In terms of socio-economic level.

5. What are your thoughts on the use of STEM approach applications based on modeling activities in mathematics?

6. What do you think about the teaching of mathematics by associating it with other disciplines?

• What is the contribution of STEM approach applications based on model eliciting activities to this situation?

7. Would you consider applying a STEM approach based on model eliciting activities in your professional life?

• If you are thinking, why do you apply it?

• In which courses do you apply it?

8. Do you have any other thoughts you would like to add?

Apart from the classroom teacher candidates, a form was created in order to get the written opinions of the students studying in the 4th grade in the primary school where the application took place, and at the end of the process, it was applied by the researcher in their own classes. Since the activities were carried out in two classes and two teacher candidates carried out the application in each class, the name of the teacher candidate who carried out the activity was written in the space at the beginning of the questions and the opinions of the students were collected separately for each teacher candidate. Interview questions are as follows.

1. What are your thoughts on the lessons you have done with your teacher?

2. .....can you compare your mathematics lessons with your other mathematics lessons with your teacher? What are the similarities and differences?

3. Do you like math class? Why do you like it or not?

4. How did your activities with your ..... teacher affect whether you liked the math lesson?

The Path Followed in the Study

In the study, the data were collected using observation and interview techniques. Observations were made by observing the activity application processes of classroom teacher candidates. The interviews were conducted with classroom teacher candidates and primary school fourth grade students who both performed and observed the application. At the end of each of the three activities, interviews were held with four prospective classroom teachers and primary school students at the end of the three activities. Interviews with prospective primary school teachers were conducted by voice recording on the researcher's phone in order to make it easier for them to progress than the note-taking technique, and they were conducted face-to-face in the researcher's office. In addition, at the end of the application process, the written form created in order to get the written opinions of the students studying in the 4th grade in the primary school where the application took place was applied by the researcher in their own classes. After the interviews were completed, the voice recordings were transcribed by the researcher.

The Analysis of the Data

In this study, qualitative data were analyzed using thematic analysis. Braun and Clarke (2006) stated that thematic analysis consists of six stages and these stages are not linear, but a

repetitive process that can be moved back and forth. The definitions of the stages and what is carried out in the stages in the data analysis process in this research are stated below:

• Researcher's familiarity with the data: It is the decoding of the data, reading the data repeatedly, and noting the first ideas. In this study, the observations of the researcher were recorded and the interview records made with the participants were deciphered. After grading and decoding, each interview text and observation notes were read repeatedly.

• Creating the first codes: It is the systematic coding of the remarkable features of the entire data set and the collection of the data related to each code. In this study, after the interviews were completed, the interview records of all three activities conducted with the practitioner teacher candidates were individually and the interview records made with the observer teacher candidates at the end of the process were associated with the teacher candidate they observed and coded by reading in detail. Then, the codes that are thought to be common are marked on the paper with the same colored pens. Two additional encodings were made by the researcher on the same data set in the same time period. Then, the codes created by the researchers were brought together and similar and different aspects were discussed, and the process continued until a common decision was made. Observation notes were brought together by the researcher to determine the common points of the application stages of each of the teacher candidates. The mentioned process was also used in the other stages (except for the preparation of the report) stated below.

• Searching for themes: It is the collection of codes under the possible themes they are related to. After the coding stage of Saldana (2013), the categories expressed a process from private to general in which the themes were reached after the categories. In this context, the codes extracted from the texts before the themes were created in this research were grouped according to their similar characteristics and combined under categories. As a result of the analysis of the observations, the stages of the activity application processes of the classroom teachers were formed and the determined stages were combined under the theme of "STEM applications based on modeling activities in the 4th grade mathematics course in primary school".

• Reviewing themes: Checking the compatibility of themes with coded data content and the entire data set, creating a thematic “map” of the analysis. In this study, possible themes created by combining subcategories, categories and categories were reviewed by researchers and coders and their compatibility with the data was checked. The consistency of the categories and whether the possible themes covered the categories were discussed by the researchers and coders and a draft thematic map was created. The stages created as a result of the observations were arranged as a result of the interviews with researchers and coders and the stages were finalized.

• Defining and naming themes: It is the simplification of the features of each theme and the clear definition and naming of each theme. In this study, possible themes created and named by the researcher were defined, and the themes were discussed with other coders and their definitions, names and content were clarified.

• Preparation of the report: Selecting concrete and convincing direct quotation samples, analyzing the coded data contents for the last time, reconnecting the analysis results with the research question and the literature, reporting the analysis in an academic language. The themes

created in this research, the categories under the themes, the subcategories and the codes that make up the categories were discussed again by the researchers and coders and finalized.

Validity and reliability in qualitative research depend on the researcher's impartial interpretation of the data and a clear explanation of all stages of the research. The researcher should clearly explain the process to other researchers who want to do a similar study after him or her. Therefore, the research process is explained in detail. In qualitative research where re-measurement and calculations cannot be made, techniques such as calculating the compatibility between observers, triangulation and confirmation of data analysis can be used (January, 2019). Qualitative validity comes from the analysis processes and expert reviews conducted by the researcher based on the information obtained from the participant observations. Reliability plays a smaller role in qualitative research. It deals with consensus-based encoder reliability on the generated codes (Creswell and Plano Clark, 2015). The reliability of the qualitative findings is improved by the researcher's explanation of the underlying assumptions and theories of the study, the use of the triangulation technique, and the detailed explanation of how the findings were reached (Merriam, 2013).

In this study, expert opinions were firstly taken in the creation of data collection tools to ensure the validity and reliability of the qualitative data collection process. The questions were examined by a total of four experts working in the fields of classroom education, developmental psychology, measurement and evaluation, and psychological counseling and guidance. Pre-application was made for the data collection tools created. During the interviews, statements that would guide the participants were avoided. Within the scope of reliability, method triangulation and data-based triangulation were used. For the purpose of method triangulation, observation, interview and document analysis were performed, and diaries and observation reports of the observer teacher candidate were examined. For data-based triangulation, data were collected from practitioner teacher candidates, observer teacher candidates and primary school 4th grade students. The interviews were recorded with the consent of the participants.

In order to establish a relationship between the researcher and the participant, the participants went to the school first and spent time with the participants. The voice recordings were transcribed by the researcher including all the words, exclamations and pauses of the participants. In this context, after the data were written, participant confirmation was applied. The participants were informed about the accuracy of the text and that it reflected their own opinions. An expert other than the researcher coded the interview text at the end of the expert coding process at the same time. At the end of the coding process, the codes, categories and themes were discussed and consensus was reached. The encoder reliability was calculated according to the Miles-Huberman method and found to be 91%.

At the end of the coding process, the researcher selected 1 random interview text and re-encoded it, and compared it with the previous coding. After the data were analyzed, a report containing the meanings obtained from the data was sent to the participants and it was confirmed whether the findings reflected their own experiences. All stages followed within the scope of the research are explained in detail. The findings were presented without commenting and without deteriorating the nature of the data, and the comments were made later. The findings were interpreted by comparing with each other.

Findings

In this section, the findings obtained as a result of the analysis of the qualitative data obtained as a result of the research are presented.

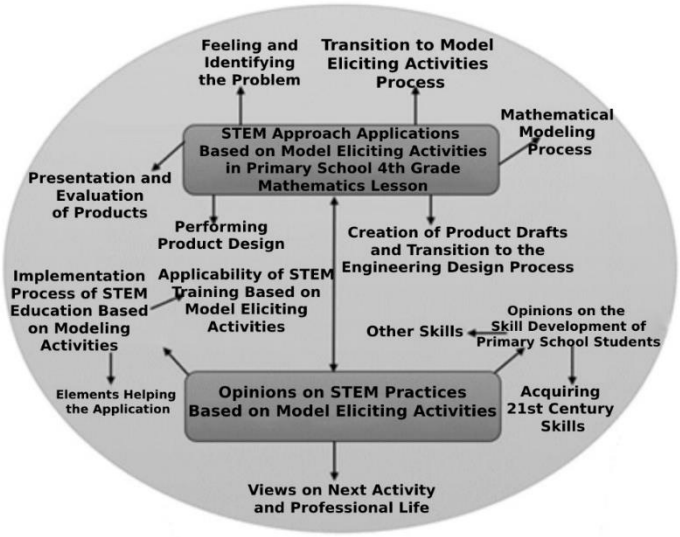

Figure 2. Qualitative data

As a result of the analysis of the course video recordings on how the STEM approach applications based on modeling activities of primary school teacher candidates and the opinions of the practitioner-observer teacher candidates and primary school students about the process, the themes of " STEM approach applications based on model eliciting activities in primary school 4th grade mathematics lesson" and "Opinions on STEM practices based on model eliciting activities" were created in the 6th Grade Mathematics Course. The stages, categories and subcategories under the emerging themes are presented in Figure 2. The results of themes, categories and subcategories are described in detail below.

STEM Approach Applications Based on Model Eliciting Activities in Primary School 4th Grade Mathematics Lesson

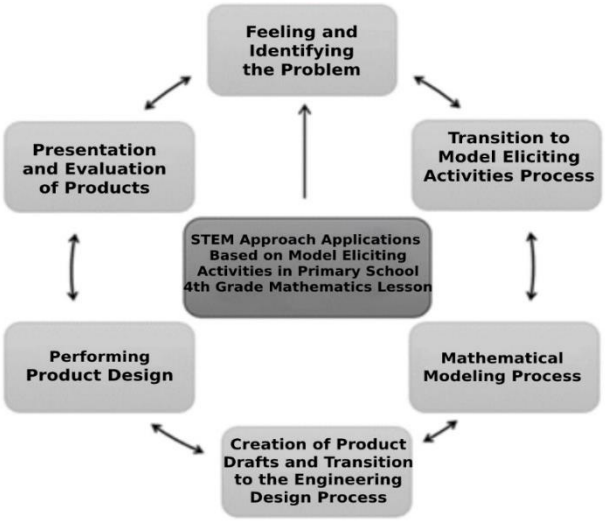

Figure 3. STEM approach applications based on model eliciting activities in primary school 4th grade mathematics lesson

When the video recordings of the course are examined, the theme of STEM approach applications based on model eliciting activities in primary school 4th grade mathematics lesson includes the stages of "feeling and identifying the problem", "transition to model eliciting activities process", "mathematical modeling process", "creation of product drafts and transition to the engineering design process", "performing product design" and "presentation and evaluation of products". As shown in Figure 3, the 6 stages mentioned consist of a cyclic process in which forward or backward transition can be made between each other. The process, which starts with students making sense of the daily life problem by doing group work and solving it with the help of mathematical modeling, is completed by product design, presentation and evaluation of the product they designed with the transition to the engineering design process. The theme of STEM approach applications based on model eliciting activities in primary school 4th grade mathematics lesson is explained below in titles to reflect the process in accordance with the order of stages.

Feeling and Identifying the Problem

When the course video recordings are examined, the first stage of STEM approach applications based on model eliciting activities is to feel and determine the daily life problem. Before starting the mathematical modeling problem, the prospective practitioners gave examples from the daily life of the students in order to understand the problem by the students, and showed examples from newspaper and television news, images from cartoons, videos or songs using smart boards. An exemplary dialogue between the teacher candidate and the students in the classroom is given below.

Teacher candidate: Now tell me what you saw in the news. (Warning not to speak without having the right to speak)

Student: Well, they showed a child with obesity.

Teacher candidate: What is obesity?

Student: Ee do not eat packaged foods too much and ee do not stop by diving into the internet, sedentary life.

Teacher candidate: As a result of this, overweight. It's called obesity, right?

Student: Yes. Exercises between the ages of three and six are mostly gymnastics.

The teacher candidate then asks the students to give examples of people who have obesity problems around them and to exemplify what they are doing to solve this problem.

In addition, when the opinions of the participants are examined, it is understood that when the mathematics course is associated with another discipline (science, art, engineering, etc.) in which the students are interested, the interest of the students in mathematics indirectly increases. At the same time, it can be said that trying to find solutions to daily life problems by associating mathematics with other disciplines also helps students to make sense of the position of mathematics in daily life. *But when we ask in this way, when I associate it with science, when I associate it with art and engineering, the child is inevitably interested in mathematics because he/she has an interest in one of those branches and can solve it more easily "," if I only studied mathematics, it would be a boring lesson, but we include science in it. For example, as in my first*

study, as in my third study, it is a dog in daily life, a means of transportation, designing them, its expenses, harming the environment, the fact that these are all related to science, it makes sense for them to act alone when children think about science besides mathematics, so it makes no sense for them to act for a purpose. I think this positively affects the use of science with mathematics." However, considering the observations and interviews, it is seen that mathematics is in the background compared to other disciplines in the activities. It can be said that taking mathematics as a basis compels classroom teacher candidates in terms of designing and implementing activities. As the teacher candidates stated, "*My first activity I designed was a little weak in that regard. While it was supposed to be mathematics-based, I realized later that I was doing it science-based "," If we think from the beginning, I had difficulty in choosing an achievement. It is also related to the grade level", "I had difficulty in finding a suitable outcome for children. Because I thought we couldn't just take every win and put it in front of them as STEM or MEA. For this reason, I had a little difficulty in looking for gains. "*

Transition to Model Eliciting Activities Process

After the stage where the daily life problem was felt and understood by the students, the teacher candidates switched to the modeling activities process. Mathematical modeling problems were distributed to students individually and students were asked to read the problem and ask about the points that were not understood. According to the results of both observation and activity plans, it can be said that the mathematical modeling problem presented to the students is related to the initially given problem situation. It was observed that teacher candidates made intensive efforts to understand the mathematical modeling problem. When the transition stage to the modeling activities process is examined separately for each classroom teacher candidate, it is seen that the process differs with small nuances due to the situations arising from different approaches in the stages of feeling and determining the problem. Although the use of modeling activities in STEM has positive reflections, it is seen that associating modeling activities with the subject within the framework of an activity within the framework of STEM in some cases compels teacher candidates. "This mathematical modeling seems to me to be like this, as if there are two separate lessons. That's why I had a little trouble. As a matter of fact, the prospective practitioners said, *"I think the first lesson is whether I should have modeling or a prototype drawn, so I think it is a little separated", "For example, we are doing a STEM activity, the child is throwing something there, how can I say, he will design something simple for you, he will design a wind-powered electrical thing for a wind, how can we add mathematics to this? Like I said, I don't think math is very prominent. They used mathematics, the math part, for what I did in STEM. Like I said, math was in it, it's not very prominent, but it was in it. It must have been effective, "*and an observer teacher candidate *said," What if, as I really said, I never thought that mathematics was fully fed into the activities. Science has always remained on top, and even mathematics has been put in the middle. So I think this is a very negative thing for the children and for us. Therefore, I have no idea what it would be like to include mathematics more, but I think better activities can be done by involving mathematics more."* This problem in adding modeling activities to STEM can be explained by the finding that STEM approach applications based on modeling activities encountered in "curriculum status" may not be suitable for every subject as mentioned in the other theme.

Mathematical Modeling Process

At this stage, after it was determined that the mathematical modeling problem was well understood by the students, it was observed that the teacher candidates directed the students to solve the problem. It is seen that teacher candidates guide the groups to find solutions through group discussions. They tried to answer the questions and needs of each group and tried to encourage students who did not participate in the group work or prevented the process to participate in the solution process again. Later, teacher candidates asked students to present the mathematical model they obtained as a result of the solution of the modeling problem with group work. In general, the first week was concluded with this presentation by the teacher candidates in the activities and they concluded the first week by stating that they wanted the students to do the second week until the other part of the activity. In Figure 4 below, an example of the mathematical modeling done by the students and the letter studies they wrote afterwards is shown.

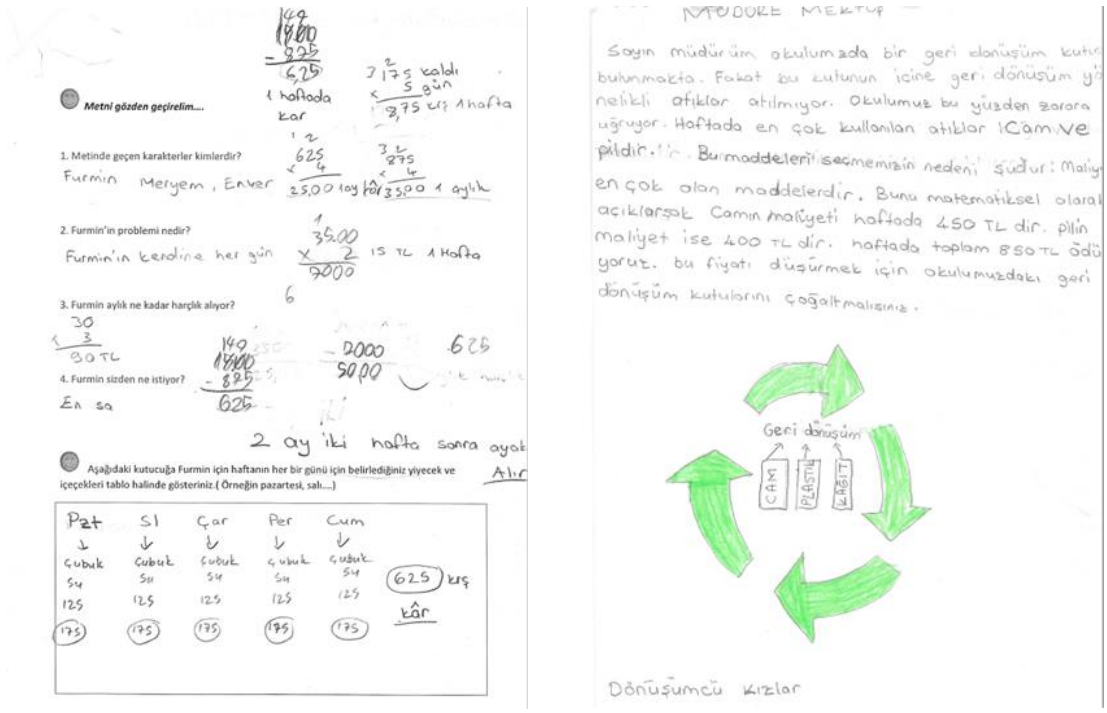

Figure 4. Mathematical modeling and examples of letters performed by students

As a result of course video recording observations and interviews with both practitioner-observer classroom teacher candidates and primary school 4th grade students, it can be stated that the use of modeling activities within the framework of a certain subject in STEM improves students' mathematics skills, better results are obtained from the application, mathematics comes to the fore in problem solving according to fields such as science and engineering, and enables mathematics to become concrete. In addition, it can be said that modeling activities can be used as a method in the use of STEM education approach in mathematics lessons. Regarding this situation, the teacher candidates stated, *"When we research in the studies, we do not see much like we do. He's usually at the center of science, but he used math as a sub-branch. But it's not like that either, we first determine the mathematical achievement or the example, or the state, then we add science to it. This is mathematics and then science in children, and in our study, they do their*

mathematical modeling and then science. If we did not use MEA for mathematical modeling, I think math would be in children, so I think they would say science, they would not say math at that time. " and" Since MEA is actually a problem, since the problem is about math, we are turning that problem into a product, I think how it could have been different. It means that we will directly explain the subject and do this, so it is important to reconcile how we reconcile. I think MEA is good right now." In addition, primary school students' *"It was a little while ago because I did not like mathematics lesson, but I like it because it was a little fun.", "It happened. Mathematical operations were very fun." "We did very nice things with teachers and maybe I would like to be a mathematics teacher when I grow up. "* The sample opinions they expressed in the form of support this situation.

Creation of Product Drafts and Transition to the Engineering Design Process

In the first dimension of the product drafting and transition to the engineering design process, it was seen that teacher candidates asked students to create two-dimensional drafts of the product they wanted them to design based on their mathematical models, which are the solutions to modeling problems, and the achievements of the science course in the problem. It is understood that this dimension, which was mostly realized immediately after mathematical modeling, was completed within the first week of the two-week process. In the second week, with the aim of transitioning to the engineering design process again, the achievements or gains of the science course, which is included in the modeling problem, were emphasized again by the teacher candidates at the beginning of the course. The first week was reminded and efforts were made to involve the students again in the process. In the video observations, the teacher candidates *said, "children, we completed our mathematical modeling in the previous lesson. Now, I'm going to tell you a little bit about the activity we're going to do next week in this class. We'll do something this week for our event next week. Now, you see next week, there's a transportation vehicle that can reach high speeds under the influence of a magnet. Now you will think of a vehicle in your mind. Look, I'm telling you, don't try to build a train just because a train is built here. It's up to you, if you want. You determine one vehicle with all your friends in the group. It may be different from the tools you see, your own design may be a tool, it may be a tool you want to make new. You'll have this car all to yourself. But there's only one thing this vehicle needs to move with a magnet. When we hold the magnet against him, the vehicle will move. We'll do that next week. We are drawing the tool we will make this week. ","* Has *everyone done their research homework? I want you to do a group sketch based on that research assignment, the distance between the two trees. Make a common decision in your trees. You will make a drawing according to what you want to have in your natural environment. You draw a drawing by paying attention to* the distance between your trees."

Performing Product Design

After the product drafts were created by the prospective primary school teachers, it was observed that the students were asked to make their drafts into a three-dimensional model using the materials requested from the previous week. The stage of designing the product carried out with group work reveals that teacher candidates have the most difficulty in classroom management and remain the most passive. At this stage, the common problem experienced by all teacher candidates is that the materials requested from the students are incomplete and as a result, the problems experienced by the teacher candidates. In cases where there was a lack of material, the problem was tried to be solved by sharing between groups or by the material

supplement brought to the class by the teacher candidates thinking beforehand. Sample views on this situation are as follows.

"Well, everything went exactly as I wanted. Well, my only problem was that the students didn't bring the supplies. It was a big problem."

"During the first lesson of the day, I asked the students if they brought any supplies. Only one of the students brought an electrical circuit."

"Only one thing happened, the issue of bringing materials. In fact, it is not about us either, it is a little bit about students, when it is about those who do not bring materials and bring missing things, that group naturally gets interrupted. That was the only problem."

"Well, one of the students did not bring his/her equipment. They shared it among themselves. He did not bring his materials... Because I saw that the students share a lot of materials. You bring this, I'll bring this, but when we look at it the next week, there are people who forget. There are people crying about it. I don't want these.".

At this stage, it may be useful to show a few examples of the products students make. As a matter of fact, two examples are shown in Figure 5.

Figure 5. Product examples made by students

Presentation and Evaluation of Products

After the students turned the products they designed into a three dimensional model, the teacher candidates asked for the presentation of their products by a spokesperson selected within the group. Students introduced their models, explained their characteristics, and opinions were received about the models introduced by other groups. A screenshot of the students' product presentation is shown in Figure 6.

Figure 6. Snapshot of students' product presentation at the end of the event

After the presentation of the products, the teacher candidates were evaluated, which is the last stage of the process, and mostly evaluation studies were carried out using pen and paper tests. However, the point that draws attention here is that there are problems of inability to catch up due to insufficient time allocated to evaluation studies. Due to the time problem, the evaluation questions were either given as homework or were asked to be completed quickly by the students and collected at the last moments of the lesson. It can be said that classroom teacher candidates generally adhere to a single method in terms of measurement and evaluation, and they are incomplete in terms of product, peer, self and process evaluation. Another missing aspect is that the evaluations do not have a corresponding score. Only one teacher candidate evaluated the questions as true and false, but this was not given to the students as a score as feedback. This may be due to the lack of knowledge and experience of teacher candidates in terms of evaluation methods, as well as the difficulty of the variety of evaluation methods in terms of time and applicability. The sample opinions of teacher candidates about the time constraints experienced during the presentation and evaluation of the products are as follows.

"Well, it was the first study, so there was a little inadequacy in time. Presentations are too late. We kept the evaluation phase short where they should have made the last presentation. We did an immediate evaluation and a late evaluation."

"At the end of the lesson, there was no time for students to present. Students delivered the products they created directly without presenting them.

Opinions on STEM Practices Based on Model Eliciting Activities

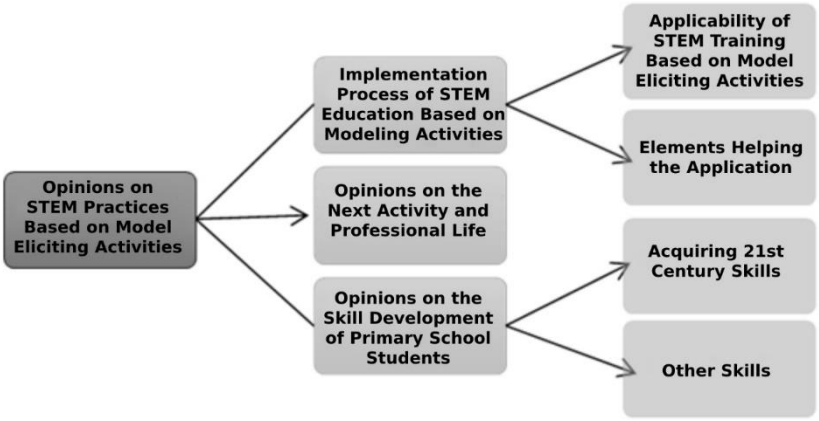

Figure 7. Opinions on STEM practices based on model eliciting activities

The theme views on STEM applications based on model eliciting activities consists of three categories and four subcategories. These categories and subcategories were obtained only as a result of semi-structured interviews and daily evaluations with the classroom teacher candidates who performed the application, interviews with the classroom teacher candidates who observed the application, daily observation reports and analysis based on the written opinions of the primary school 4th grade students. Under this theme, which includes findings that cannot be associated with the observations of the course video recordings and cannot be obtained from the observations, there are three categories called "implementation process of STEM education based on modeling activities", "opinions on the next activity and professional life" and "opinions on the skill development of primary school students". In addition, the category of implementation process of STEM education based on modeling activities consists of the subcategories of "applicability of STEM training based on model eliciting activities" and "elements helping the application". The category of opinions on the skill development of primary school students is "acquiring 21. century skills" and "other skills" subcategories.

Implementation Process of STEM Education Based on Modeling Activities

The application process category of STEM education based on modeling activities consists of "applicability of STEM education based on modeling activities" and "elements that help implementation" subcategories. The Applicability of STEM Education Based on Model eliciting Activities subcategory refers to the general situations that affect the applicability of the approach used in primary school 4th grade mathematics course, are outside the control of the teacher candidate, and affect whether the application can be made or not. As seen in Table 3, the codes of this sub-category are determined as "physical conditions", "student level", "curriculum status", "socio-economic level".

Table 3. *Participants' opinions on the applicability of STEM education based on model eliciting activities*

Subcategory	Code
Applicability of STEM Training Based on Model eliciting Activities	Physical conditions
	Student Level
	Curriculum status
	Socio-economic level

Examples of the opinions of the participants in this subcategory are presented below.

"We can also talk about the crowd of the classroom in terms of its physical structure. Well, I think STEM studies need to be done with fewer people. Our classroom was 22, 23, 25 people in general for weeks, and when this class is crowded, there is more noise, of course, we want them to talk, we want them to help, but when it is more crowded, the teacher candidate gets angry, cannot make his voice heard, the children do not listen, so I think it would be more appropriate for more than fifteen people. The number of our class was too many."

"Primary school is actually very important in this respect. Rather than starting in secondary school, I find it useful to start in primary school or even in preschool before primary school."

"I see this as difficult, but they can make thoughts about turning an abstract into concrete during the transition to the new secondary school in four, but I don't think they can do it in less than three, so I don't think they can do it in less than four... So it's feasible, but it's a little bit of a thing to

wait for the product to come out. I have a pessimism about that. We can wait for the product after four, but if necessary, it can be applied for STEM other than the product. "

"The curriculum situation, as we said, can fit every achievement even if it does not fit everything, I think it should be applied to the achievements and should not be missed."

"It is only my problem that it is in the direction of this achievement. Because ee 5, 6, 7. 8. There are so many achievements in classrooms to do STEM that you can do as much as you want, so you can do STEM in the classroom. I only have a little difficulty in the levels until this 4th grade... There's a bit of a problem with the curriculum. Of course, you can do it as a science, but you can also be a little out of your league. I don't know how true that would be."

"I mean, I think, if I go to a village school, how much can I do it? I can do this at most once a month, once every two months, but in private schools, I think it is applicable every week. Financially troubled throughout Turkey "

The subcategory of elements that help implement modeling activities-based STEM education in the application process category refers to primary school 4th grade mathematics classroom teacher candidates and situations that positively affect the application while applying modeling activities-based STEM education. As seen in Table 4, the codes of this category are determined as "classroom teacher support", "grouping students", "appropriate subject selection" and "student readiness".

Table 4. *Participants' Views on the Factors Helping the Application*

Subcategory	Code
Elements Helping the Application	Classroom teacher support Grouping students Appropriate topic selection Student readiness

Examples of the opinions of the participants in this subcategory are presented below.

"I think I have already received support from the teacher. He's already been very helpful with the, uh, supplies. He was the one who told the students about the materials."

"There is something like this in group work. I think it would be very good if a heterogeneous group was formed... How can I describe it properly? I think it would be very good cooperation and working together in line with a common goal if the students were really recognized and created according to their characteristics."

"The fact that the subject I chose was interesting made my job easier. For example, the fact that there is a puppy in this subject that I have chosen attracts more attention in children, so they have taken more ownership of the subject or I think they are more inclined to the subject because they think of someone who needs help."

"Well, they knew about it. They already know the four-digit process. They already know the other, uh, science part. I just came on to you... He may have just made it easier on himself. Because the students had to reapply what they learned in STEM."

Opinions on the Next Activity and Professional Life

This category covers the findings obtained by analyzing the opinions of prospective classroom teachers in terms of both the activity they will design and apply and their use in their professional lives as a result of the application of STEM education based on modeling activities in the 4th grade mathematics course of primary school. As seen in Table 5, the codes of this category are determined as "planning time", "acquisition and subject selection" and "using in professional life".

Table 5. *Participants' views on next activity and professional life*

Category	Code
Views on Next Activity and Professional Life	Scheduling time Acquisition and topic selection Use in professional life

Examples of the opinions of the participants in this category are presented below.

"I will definitely be more careful in the timing part once in the leap time part. The timing didn't go with my original plans. I'll tell you, I've had problems in general. I will fix it at the beginning, I will keep the time wider now. "

"Actually, we are starting from the gains here, so the gains can actually be applied, but I don't know if they can be applied in line with the gains. For us, for example, with the gains, there will be both science gains and mathematics gains. Of course, these will already be at the level of 4th grade, and this will also do this in the classroom. For example, if it progresses in the direction of a single gain, for example, if it does not associate science with mathematics, or if mathematics can be done with science, it seems to be easier to apply this way... For example, this will probably not be the case at my event. It will be easier for them to understand and easier for them to do. That's my opinion.

"Honestly, I can't do it every week. I can't do as I say in every subject, but I definitely want to do it","I use it, I definitely use it... So I don't do anything in a single course, but I don't know your class in any course, I mean, according to the efficiency I will receive from them, I will definitely use it every two weeks, every three weeks, maybe once a month. I'd like to use it. In fact, I do not use it for a single course, as I said, it is not a single course, because it covers all courses. I don't know once a week, it can be in any class."

"Of course I do. I take the child from the foundation, develop him/her, of course, I would like to develop his/her 21st century skills floor by floor. I don't normally want to be a flattened teacher. I definitely run the STEM application for him. I apply them for the child's own development."

Opinions on the Skill Development of Primary School Students

The effect of the activities applied in the process of applying the STEM education approach based on modeling activities in the 4th grade mathematics course on the skill development of primary school students category "21. Century skills" and" Other Skills". 21. The acquisition of 21st century skills subcategory includes the findings related to the observation of the acquisition of basic 21st century skills aimed by the STEM approach as a result of the application of the STEM education approach based on model eliciting activities in the 4th grade mathematics course of

primary school. As seen in Table 6, the codes of this subcategory are determined as "cooperating", "communication", "creativity" and "critical thinking".

Table 6. *Participants' 21st 20th century skills*

Category	Code
Acquiring 21st Century Skills	Collaboration Contact Creativity Critical Thinking

Examples of the opinions of the participants in this subcategory are presented below.

"They learned to work together, they learned creativity, they had fun, the lesson was more fluid, it was easier. That's why I think it has benefits."

"Group work, they communicate together, they decide something common together. Here they make joint decisions, they do this in the case of group work... For example, someone is making the wheel of the car, someone is making the body, someone is dealing with the decoration, someone is saying that we will make patterns like this here, so they are all talking together, they are in communication."

"They exchanged ideas within the group while dealing with each group design", "It was good for the exchange of ideas. If I think about it, it was also good for communication"

"As I said about the benefits to children, I think that creativity definitely increases their creativity for the first time. Because we leave it original, you know, he chooses one of the many options and does it himself. "

"I think it is very effective in terms of critical point of view", "at work I can think critically, I can take problems from daily life", "the child can think critically and because he/she does this with a group, he/she takes everyone's opinion, I think there are very different perspectives"

The Other Skills subcategory includes the findings of the situations observed in the students as a result of the application of the STEM education approach based on modeling activities in the 4th grade mathematics course of primary school and the experiences of the students regarding some of these situations. As seen in Table 7, the codes of this subcategory are determined as "interest and motivation", "abstract thinking", "psychomotor skills", "spatial thinking", "experience", "using the given time", "working with the group" and "mathematical modeling".

Table 7. *Participants' Opinions on Other Skills Category*

Category	Code
Other skills:	Interest and Motivation Abstract Thinking Psychomotor skills Spatial Thinking of Experience Using the Given Time Working with the Group Mathematical Modeling

Examples of the opinions of the participants in this subcategory are presented below.

"Well, the lessons were fluent, attracted the attention of the children, mostly because it was a design, drawing and they put it into practice."

"I was very happy to see that the students enjoyed themselves and laughed during the lesson."

"But when I went to the internship yesterday, I noticed. The kids come right up to me and say, "When are we going to do the activity?" When should we bring the supplies?"

"I think it makes it easier for children to think abstractly", "I think I make them think because I teach indirectly instead of giving direct gain in another job."

"As I said, they work together within the group, their psychomotor skills develop together, they cut and draw."

"When I was modeling the reading text in another job, they did not understand this so that they would think of a three-dimensional car style on a cardboard cardboard. There were those who made it in two dimensions "," even when you say we will model them, they were surprised and so on."

"For example, I think that children have come a long way for group work because they have never done any group work until today and when they work in groups, they have a really great development when I compare the weeks, the first activity and the third activity. You know, for group, teamwork."

"It was very nice, I liked these 3 activities very much. She told us very beautifully. I liked it as much as we could understand.", "It was nice, I was happy. I was very pleased. "," I thought I liked the lessons very much, I wish I could do the activity again. ", I think it was good, our teacher made us very happy, it was very good, our lesson was very good."

Discussion and Conclusion

Student-level model eliciting activities have emerged as one of the factors affecting the applicability of the STEM approach. In their first activities, teacher candidates had difficulty in designing and implementing activities for the STEM approach based on model eliciting activities suitable for the 4th grade student level of primary school. However, with the experiences they gained in other activities, it was revealed that they exceeded the difficulties they experienced in terms of student level. Similarly, there are studies in the literature indicating that student level is important in STEM activities, the level of association of STEM disciplines increases as the grade level increases, and that it is an effective factor in implementing activities (Kaya and Ayar, 2020; Korucu and Kabak, 2021). In this direction, it makes sense that the participants had difficulty in their first activities. There are positive results such as increased success, better understanding of the subject and permanent learning in the classes where STEM activities are applied (Acar, Tertemiz and Taşdemir, 2018; Alumbaugh, 2015; Becker and Park, 2011; Bolat, 2020; Herdem and Ünal, 2018; Kanadlı, 2019; Seage and Türegün, 2020; Siregar, Rosli, Maat and Capraro, 2020). In addition, in the study conducted by Akgündüz and Akpınar (2018), it can be thought that STEM education practices positively affect students in terms of both academic achievement and skill development, and that Becker and Park (2011) found the largest effect size of the STEM approach at primary school level according to school levels. In this study, it was concluded that STEM activities could be applied at the level of primary school 4th grade students and that the activities could make positive contributions to the students.

The situation expressed by the curriculum status, which is one of the factors affecting applicability, covers that the units, subjects and achievements of primary school mathematics and science course are partially appropriate for the realization of the STEM approach based on modeling activities in schools. There are studies in the literature in which it is concluded that the existing school curricula shaped within the framework of the knowledge-based exam system limit the STEM education approach practices. It has been stated that these limits STEM from students' exam anxiety (Doğan, 2019; Kanadlı, 2019; Kaya and Ayar, 2020; Korucu and Kabak, 2021; Mumcuoğlu Topaloğlu, 2020; Uğraş, 2017). It is seen that the competencies expected from the students within the scope of Turkey Competencies Framework in Ministry of Education curricula are mostly similar to the expectations of STEM. However, although there is a step in the STEM action plan of Ministry of Education (2016) to update the curricula to include STEM education, there is no gain or skill related to STEM in the primary school mathematics curriculum. In the science curriculum, there is a STEM study at the end of each unit and it is even recommended that the products made by the students be presented at the end of the year under the name of science festival. Similarly, it can be said that additions are necessary to integrate STEM in the mathematics curriculum. This situation coincides with the findings obtained in this study that the curriculum situation is partially suitable for STEM practices.

According to the opinions of the participants, it can be said that when the mathematics course is associated with another discipline (such as science, art, engineering) or disciplines, the interest of the students in mathematics increases. When the literature is examined, it is seen that STEM applications allow students to learn with an interdisciplinary approach by crossing the boundaries of a discipline (Eroğlu and Bektaş, 2016; Kanadlı, 2019; Kaya and Ayar, 2020; Kopcha et al., 2017; Siew, Amir and Chong, 2015; Uğraş, 2017). At the same time, it is possible to see that STEM education positively affects students' creative thinking skills by allowing interdisciplinary education (Gülhan and Şahin, 2018) and that teacher candidates have a positive effect on their perceptions of interdisciplinary education (Herdem and Ünal, 2018; Korucu and Kabak, 2021; Yıldırım and Gelmez-Burakgazi, 2020). In addition, there are studies showing that students prefer STEM activities presented with an interdisciplinary approach (Doğan, 2019; Hiğde, 2018). However, within the scope of STEM activities, there are also studies in which mathematics remains weak in relation to daily life compared to other disciplines (Akgündüz and Akpınar, 2018), the interdisciplinary mathematics course has no significant effect on students' problem solving skills (Dickerson, Eckhoff, Stewart, Chappell and Hathcock, 2014; Elliott, Oty, McArthur and Clark, 2001), and among the disciplines that make up STEM, mathematics has the least effect size in terms of success compared to other disciplines (Becker and Park, 2011). Considering that the participants expressed a positive opinion that the application of the STEM approach based on modeling activities increased students' interest in mathematics, it can be stated that mathematics can be beneficial in terms of associating it more strongly with daily life.

Participants stated that they had difficulty in establishing context integration in terms of basing mathematics and placing mathematics lesson learning outcomes and subjects in STEM activity. In the observations made, it is seen that some teacher candidates have difficulty in establishing context integration. Similarly, when the literature is examined, it is possible to see studies indicating the difficulty of combining different disciplines in a context (Estapa and Tank, 2017; Firdaus, Wardani, Altaftazani, Kelana and Rahayu, 2020; Kaya and Ayar, 2020; Lidinillah,

Mulyana, Karlimah and Hamdu, 2019; Uğraş and Genç, 2018; Weber, Fox, Levings and Bouwma-Gearhart, 2013). Among the reasons for difficulty in context integration, it can be thought that there is a lack of sufficient information about how to integrate STEM activities and lack of resources and support (Weber, Fox, Levings and Bouwma-Gearhart, 2013). Weber, Fox, Levings, and Bouwma-Gearhart (2013) point out that when situations such as lack of knowledge, lack of resources and support are eliminated, it can be thought that the problems experienced in context integration will decrease.

Participants stated that modeling activities could be an appropriate method in the application of STEM in mathematics lesson. Studies on the subject also show that STEM is effective in mathematics success (Berk, 2020; Bolat, 2020; Hakim, Sulatri, Mudrikah and Ahmatika, 2019; Hiğde, 2018; Kim and Choi, 2012; Prawvichien, Siripun and Yuenyong, 2018; Siregar, Rosli, Maat and Capraro, 2019) and positively affects students' attitudes towards mathematics (Ching, Yang, Wang, Baek, Swanson and Chittoori, 2019). At the same time, within the scope of STEM activities, students experience how they can apply their mathematics knowledge in practice (Kopcha et al., 2017; Wieselmann, Roehrig, & Kim, 2020). Doğan, Gürbüz, Çavuş-Erdem and Şahin (2019) stated that STEM activities can be done by using an interdisciplinary mathematical modeling framework and this can be a tool to overcome the difficulties in solving real-world problems. When we look at Doğan's (2019) research, it can be seen that applying STEM activities based on mathematics can make mathematics topics more fun and understandable. Compared to other disciplines, the difficulty of placing mathematics in STEM activities is also known (Lidinillah, Mulyana, Karlimah, & Hamdu, 2019). In this study, the participants stated that they had difficulty in basing mathematics on STEM activities, but they stated that modeling activities were an appropriate method to overcome this difficulty.

At the end of the activity, the participants stated that they generally used pen and paper tests, presentation and product evaluation during the measurement and evaluation phase. They generally used peer evaluation by making students in other groups comment after product presentation, but it is seen that they did not use an evaluation form. It can be said that they are incomplete in terms of self-evaluation. A similar situation is seen as a result of the observations made and the examination of the activity files of the participants. In the literature, it is stated that measurement and evaluation have an important place in STEM activities, in this way, information about students' performance and learning levels can be obtained and activities can be organized in the light of this information (Pulat, 2020; Zengin, Kaya and Pektaş, 2020). It is understood that measurement and evaluation were made in the majority of the studies conducted using STEM activities. In the measurement and evaluation dimension, the ability to use the presentation method more frequently than other methods in the evaluation phase of STEM activities (Pulat, 2020) is also important for the development of communication skills within the scope of 21st century skills. Although there are deficiencies in terms of evaluation types in this study, it can be thought that the evaluation types used by the participants are sufficient.

The use of the STEM approach based on modeling activities in the professional lives of the participants includes the frequency of activities, the course to be based on and the motivation factors. It was stated that the activities could not always be done, but when the benefits were considered, they should be done once in the period. Similarly, it is possible to come across findings

that teachers use STEM-based activities as extracurricular exercises in the lesson by considering various criteria (Eroğlu and Bektaş, 2016). However, from the perspective of the students, it can be seen that such activities are requested to be applied more frequently (Doğan, 2019). Regardless of how often it is used, it has been observed that teacher candidates have various motivations to use such activities in the future. Participants' interest in using such activities in the future, trying to solve the problem with real life, providing the student with basic 21st century skills and lesson repetition are the sources of motivation. When the literature is examined, it is seen that teachers and teacher candidates generally develop positive attitudes towards STEM practices and contribute to professional development (Alumbaugh, 2015; Herdem and Ünal, 2018; Kaya and Ayar, 2020; Korucu and Kabak, 2021; Uğraş, 2017; Uğraş and Genç, 2018).

According to the opinions of the participants, it was determined that the basic 21st century skills (collaboration, communication, creativity and critical thinking) aimed by the STEM approach were observed in the fourth grade students as a result of the application of the STEM approach based on modeling activities in the 4th grade mathematics course of primary school. Similar to this finding, many studies show that STEM practices positively affect students' 21st century skills (Akgündüz and Akpınar, 2018; Hiğde, 2018; Kanadlı, 2019; Kaya and Ayar, 2020; Korucu and Kabak, 2021; Uğraş, 2017; Uğraş and Genç, 2018). However, in some studies, it is also noteworthy that STEM activities do not have an effect on STEM 21st century skills (Doğan, 2019). The difference between the study of Doğan (2019) and this study may be due to the differences in the data collection tool (interview-achievement test), sample (teacher candidate-seventh grade student) and method (qualitative-quantitative) between the two studies.

As a result of the application of the STEM approach based on modeling activities, the participants stated that the students had positive and negative experiences in terms of interest and motivation, abstract thinking, psychomotor skills, spatial thinking, experience, using the given time, working with the group and mathematical modeling. It is seen that most of the STEM activities performed allow students to make their own decisions and do their own research throughout the process, are fed by current teaching approaches that provide meaningful learning, provide permanent, effective learning, and are designed as student-centered on its basis (Kaya and Ayar, 2020; Pulat, 2020). Considering the ratio of learning by doing and experiencing among other forms of learning, it can be thought that STEM activities provide a suitable learning environment for the student.

Participants stated that students' interest and motivation in the course and subject increased as a result of the application of the STEM approach based on modeling activities. In addition, they stated that the fact that the application made in this increase was different for the students compared to other courses, product creation as a result of the application, active participation of the student in the application process and the application process being fun for the student were effective. Primary school students also have statements stating that the lessons they do are more fun than other courses. As seen in the literature, although there may be differences in attitudes towards STEM depending on many variables (gender, parental education level, computer or internet ownership status, etc.) (Azgın and Şenler, 2019; Korucu and Kabak, 2021), similar to this study, it is possible to come across studies showing that STEM applications are fun for students and increase students' interest and motivation in the learned subject (Acar,

2018; Acar, Tertemiz and Taşdemir, 2018; Afriana, Permanasari and Fitriani, 2016; Akgündüz and Akpınar, 2018; Arık and Benli Özdemir, 2019; Berk, 2020; Bolat, 2020; Ching et al., 2019; Doğan, 2019; Eroğlu and Bektaş, 2016; Hacıoğlu and Başpınar, 2020; Kanadlı, 2019; Kaya and Ayar, 2020; Kopcha et al., 2017; Korucu and Kabak, 2021; Saka, 2020; Captain and Katrancı, 2020; Siewir, 2015; Amrong, 2015; Tomca and Greş, 2015; Ultğra, 2017; Ultaş, 2017; Yasmak, 2017).

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BIOGRAPHICAL NOTES

Contribution Rate of Researchers

Author 1: 50%

Author 2: 50%

Conflict Statement

There is no material or individual organic connection with the people or institutions involved in the research and there is no conflict of interest in the research

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Sınıf Öğretmeni Adaylarının İlkokul 4. Sınıf Matematik Dersinde Model Oluşturma Etkinlikleri Temelli STEM Yaklaşımı Uygulamalarının İncelenmesi

Giriş

Araştırmalar, matematik ve fen bilimlerini bütünleştirmenin öğrenmeyi daha bağlantılı ve alakalı hale getirdiğini ve öğrencilerin okula karşı tutumları ve ilgileri, öğrenme motivasyonları ve başarıları üzerinde olumlu bir etkisi olduğunu göstermiştir (Stohlmann, 2013a). Gittikçe karmaşıklaşan problemleri çözmek için multidisipliner yaklaşımların ve becerilerin gerekli olduğu günümüz dünyasında, ilgili disiplinlerin bütünlüğünün korunması ve öğretmenlerin gerekli bilgi, bağlılık ve kaynaklarla donatılmasıyla bütünleştirilmiş STEM etkinliklerini içeren okul müfredatı eğitimde ilerleme için olumlu bir adım gibi görünmektedir (English, 2017). STEM eğitim yaklaşımı uygulanan çalışmaların meta analizinin yapılması sonucu STEM eğitimi programlarının öğrencilerin matematik başarısına olumlu katkı yaptığı ve bu katkının istatistiksel olarak anlamlı olduğu sonucuna varılmıştır (Siregar, Rosli, Maat ve Capraro, 2019). Ancak matematiğin diğer tüm STEM disiplinlerini desteklediği yaygın olarak kabul edilse de bütünleştirilmiş STEM eğitiminde hafife alınan bir rol oynadığına dair açık kanıtlar vardır (Maass, Geiger, Ariza ve Goos, 2019). Mühendislik eğitiminin ağırlıklı olarak fen müfredatına dayanarak gerçekleştirilmesi ile matematiğin arka planda kalmasına yol açmasına izin verilmemelidir (English, 2015).

Maass, Geiger, Ariza ve Goos (2019) STEM etkinliklerinde matematiğin rolünü arttırmak için önerdiği yöntemlerden birinde matematiksel modellemenin okul müfredatına anlamlı bir şekilde dâhil edilmesinin gerekli olduğunu söylemektedir. Matematiksel modellemenin uygulama yöntemlerinden biri olan "model oluşturma etkinlikleri" ise STEM eğitiminin matematik dersinde kullanımına yönelik alternatif olarak ortaya çıkmıştır. Ancak tek başına model oluşturma etkinlikleri mühendislik becerisi ve disiplinler arası öğrenmenin gerçekleşmesinde yeterli olmayabilir. Benzer şekilde Lesh (2010) model oluşturma etkinliklerinin tam bir müfredat olmasından ziyade bir dersin içeriğini tamamlaması amaçlayan etkinlikler olduğunu ifade etmiştir. STEM eğitimi alanyazını incelendiğinde matematiksel modellemenin önemini görmek

mümkündür ancak aynı zamanda STEM disiplinleri arasında bir köprü olarak modellemenin doğası hakkında yapılmış sınırlı sayıda araştırma bulunmaktadır (Hallström ve Schönborn, 2019). Bunun yanında model oluşturma etkinliklerinin kullanılmadığı STEM etkinlikleri uygulaması sonrası ilköğretim matematik öğretmen adaylarında matematiksel düşünme ve problem çözme becerilerinde değişiklik olmadığı (Yıldırım ve Sidekli, 2018) ifade edilen çalışmadan yola çıkarak, model oluşturma etkinliklerinin STEM yaklaşımının matematik temelli uygulamasında kullanılması sonucu elde edilecek sonuçları görmenin alanyazına katkısı olabileceği düşünülebilir.

Alanyazın taraması sonucu model oluşturma etkinliklerinin STEM eğitim yaklaşımın matematik bağlamında uygulayabilmek için kullanılabilecek bir yöntem olduğunu söylemek mümkün görünmektedir. Bu bağlamda; bu araştırmada model oluşturma etkinlikleri temelli STEM yaklaşımının ilkokul düzeyinde uygulanabilirliğini araştırmak amaçlanmıştır. Türkiye'de STEM yaklaşımına yönelik öğretmen adayı eğitimi alanında yapılan araştırmalar uygulama türünde olup, STEM ile ilgili teorik bilgi ve etkinlikleri içermektedir ve yaklaşık yarısı son 3 yılda gerçekleştirilmiştir. Bu çalışmalarda örneklemler çoğunlukla fen bilgisi öğretmenleridir (Gül ve Taşar, 2020). Nitekim yapılan çalışmalar göz önüne alındığında STEM eğitimi yaklaşımının matematik dersi kazanım ve konularının temele alınarak, ilkokul düzeyinde kullanılması ve sınıf öğretmeni adayları örnekleminde uygulamalarının eksikliği göze çarpmaktadır. Ayrıca matematiksel modellemenin STEM eğitimi yaklaşımının matematik temelli uygulanmasında bir yöntem olabileceğine dair araştırmalar dikkate alındığında, Türkiye'de bu alanda araştırmaların eksikliği görülmektedir. Bu bağlamda bu araştırmada sınıf öğretmeni adaylarının bir devlet okulunda, sınıf ortamında uyguladıkları, araştırmacı tarafından modeli ortaya konulan model oluşturma etkinlikleri temelli STEM yaklaşımı uygulamalarının, ders video kayıtlarının gözlemlenmesiyle, uygulamaların ilkokul 4. sınıf matematik dersinde sınıf öğretmeni adayları tarafından nasıl gerçekleştirildiğinin ve uygulayıcı-gözlemci sınıf öğretmeni adayları ile ilkokul öğrencilerinin uygulamaların kullanımına yönelik görüşlerinin incelenmesi amaçlanmıştır. Araştırmanın alanyazında bahsedilen eksikliği gidereceği ve aşağıda yer alan problemlere cevap vereceği düşünülmektedir.

•Katılımcıların model oluşturma etkinlikleri temelli STEM yaklaşımı uygulamaları sürecinde kullandıkları aşamalar nelerdir?

•Katılımcıların model oluşturma etkinlikleri temelli STEM yaklaşımı uygulamaları sürecine yönelik görüşleri nedir?

•Katılımcıların model oluşturma etkinlikleri temelli STEM yaklaşımı uygulamaları süreci sonunda bir sonraki etkinlik ve mesleki yaşama ilişkin görüşleri nedir?

•Katılımcıların model oluşturma etkinlikleri temelli STEM yaklaşımı uygulamaları sürecinin ilkokul öğrencilerinin beceri gelişimine etkisine ilişkin görüşleri nelerdir?

Yöntem

Araştırma Modeli

Araştırmada nitel araştırma yöntemlerinden "temel nitel araştırma" deseni kullanılmıştır. Temel nitel araştırmada araştırmacılar insanların yaşamlarını nasıl yorumladığına, kendi dünyalarını nasıl inşa ettiğine ve deneyimlerine kattıkları anlamların ne olduğuyla ilgilenirler. Temel amaç insanların yaşam ve deneyimlerini nasıl kavradığını anlamaktır. Temel nitel

araştırma eğitimde kullanılan en yaygın tür olabilir. Veriler gözlem, görüşme ya da doküman analizi ile toplanır. Veri analizi tekrarlayan örüntüleri belirlemek için yapılır. Ortaya çıkan verilerden elde edilen temalar bulguları oluşturur (Merriam, 2013). Araştırmada gözlem ve görüşme ile nitel veriler toplanmış ve araştırma nitel araştırma paradigmasına dayanarak yürütülmüştür. Var olan durumu ortaya koymaktan ziyade müdahale edilmiş ve amaçlı olarak değiştirilmiş ortamdan veri toplanmış olduğu için diğer nitel araştırma desenleri yöntem olarak ifade edilmemiştir. Bu tip durumlarda genellikle alanyazında araştırma deseni olarak kullanılan temel nitel araştırma deseni yöntem olarak tercih edilmiştir.

Çalışma Grubu

Araştırmada süreci yürütmek üzere seçilen öğretmen adayları amaçlı örnekleme yöntemlerinden maksimum çeşitlilik örneklem seçimine göre belirlenmiştir. Maksimum çeşitlilik örneklem seçiminde bireylerin çeşitliliğin maksimum düzeyde temsil edilmesi amacıyla küçük bir örneklem üzerinde çalışılır. Amaç çeşitlilik gösteren bireylerin benzer ya da farklı olduğu noktaları ortaya koymaktır (Gezer, 2021). Sınıf öğretmeni adaylarına uygulama aşamasından önce 2018-2019 öğretim yılı bahar döneminde 3. sınıfta öğrenim görürken, Matematik Öğretimi II dersi kapsamında model oluşturma etkinlikleri temelli STEM yaklaşımı uygulama sürecine uygun etkinlik tasarlama eğitimi verilmiştir. Eğitimin sonunda tasarladıkları etkinliklerden aldıkları puanlara göre, en yüksek (85 puan ve üzeri), en düşük (50 ile 64 arası) ve ortalama puan (65 ile 84 puan arası) alan öğretmen adayları arasından sekiz öğretmen adayı gönüllülük esasına göre seçilmiştir. Buna göre iki aday en yüksek puan alan, iki aday en düşük puan alan ve dört aday ise ortalama puan alan öğretmen adayları arasından belirlenmiştir. Puan üzerinden örneklem seçimi yalnızca çeşitliliği artırma amaçlı yapılmıştır, araştırma sürecinde herhangi bir şekilde değişken olarak kullanılmamıştır. Seçilen çalışma grubunun altısı kadın ikisi ise erkektir. Bu sekiz öğretmen adayı arasından bir en yüksek, bir en düşük ve iki ortalama puan alan öğretmen adayı etkinlik tasarlamış ve 2019-2020 öğretim yılı güz döneminde Öğretmenlik Uygulaması I dersi kapsamında bir devlet ilkokulunda eğitim gören 4. sınıf öğrencilerine uygulamışlardır. Diğer dört öğretmen adayı ise gözlemci statüsünde derslere katılım sağlamışlardır.

Veri Toplama Araçları ve Verilerin Toplanması

Araştırmada veri toplamak amacıyla gözlem ve görüşme tekniği kullanılmıştır. Sınıf öğretmeni adaylarının etkinlik uygulama süreçlerini incelemek amacıyla araştırmacı tarafından ders video kayıtları gözlemlenmiştir. Gözlem sürecinde etkinlik uygulama süreci notlar alınarak, sınıfta geçen öğretmen-öğrenci diyalogları ve öğretmen-öğrenci davranışları incelenerek yürütülmüştür. Dolayısıyla herhangi bir gözlem formu kullanılmamıştır. Yapılandırılmamış gözleme göre yapılan incelemeler sonucu elde edilen veriler katılımcıların uygulama süreci ile ilgili görüşleri ile de bağdaştırılarak analiz edilmiştir. Ayrıca sınıf öğretmeni adaylarının görüşlerini belirlemeye yönelik yarı yapılandırılmış görüşme formu hazırlanmış ve uygulanan üç etkinliğin her birinin sonrasında sınıf öğretmeni adaylarıyla görüşme yapmak için kullanılmıştır. Ayrıca uygulamayı gerçekleştiren sınıf öğretmeni adaylarının sınıflarında bulunan gözlemci sınıf öğretmeni adaylarıyla sürecin sonunda gözlemlerine yönelik görüşlerini belirlemek için farklı bir yarı yapılandırılmış görüşme formu hazırlanmış ve uygulanmıştır.

Verilerin Analizi

Bu araştırmada nitel veriler tematik analiz kullanılarak analiz edilmiştir. Braun ve Clarke (2006) tematik analizin altı aşamadan oluştuğunu ve bu aşamaların doğrusal olmadığını, ileri geri gidilebilen tekrarlı bir süreç olduğunu ifade etmişlerdir. Aşamaların tanımları ve bu araştırmada veri analiz sürecinde aşamalar içerisinde gerçekleştirilenler aşağıda ifade edilmiştir:

Araştırmacının veriye aşina olması: Verinin deşifre edilmesi, verinin tekrarlı şekilde okunması, ilk fikirlerin not edilmesidir. Bu araştırmada da araştırmacının gözlemleri notlara dökülmüş ve katılımcılarla yapılan görüşme kayıtları deşifre edilmiştir. Notlandırma ve deşifre sonrasında her görüşme metni ve gözlem notları tekrarlı şekilde okunmuştur.

İlk kodların oluşturulması: Tüm veri setinin dikkat çeken özelliklerinin sistematik bir şekilde kodlanması ve her bir kodla alakalı olan verilerin bir araya toplanmasıdır. Bu araştırmada görüşmeler tamamlandıktan sonra uygulayıcı öğretmen adaylarıyla yapılan her üç etkinliğin görüşme kayıtları ayrı ayrı ve gözlemci öğretmen adaylarıyla süreç sonunda yapılan görüşme kayıtları ise gözlemlediği öğretmen adayıyla ilişkilendirilip detaylı okunarak kodlanmıştır. Daha sonra ortak olabileceği düşünülen kodlar aynı renkli kalemlerle kâğıt üzerinde işaretlenmiştir. Aynı zaman diliminde aynı veri seti üzerinde iki ayrıca araştırmacı tarafından kodlama yapılmıştır. Daha sonra araştırmacıların oluşturduğu kodlar bir araya getirilerek benzer ve farklı yönler tartışılmış, ortak bir karar verilene kadar süreç devam etmiştir. Gözlem notları ise öğretmen adaylarının her birinin uygulama aşamalarının ortak noktalarını belirlemek amacıyla araştırmacı tarafından bir araya getirilmiştir. Bahsedilen süreç aşağıda ifade edilen diğer aşamalarda da (raporun hazırlanması hariç) kullanılmıştır.

Temaların aranması: Kodların ilişkili oldukları olası temaların altında toplanmasıdır. Saldana (2013) kodlama aşamasından sonra kategoriler, kategorilerden sonra temalara ulaşılan özelden genele doğru bir süreci ifade etmiştir. Bu bağlamda bu araştırmada temalar oluşturulmadan önce metinlerden çıkarılan kodlar benzer özelliklerine göre gruplandırılarak kategoriler altında birleştirilmiştir. Gözlemlerin analizi sonucu ise sınıf öğretmenlerinin etkinlik uygulama süreçlerinin aşamaları oluşturulmuş ve belirlenen aşamalar "İlkokul 4. sınıf matematik dersinde model oluşturma etkinlikleri temelli STEM uygulamaları" teması altında birleştirilmiştir.

Temaların gözden geçirilmesi: Temaların, kodlanmış veri içeriğiyle ve tüm veri setiyle uyumunun kontrol edilmesi, analize ilişkin tematik 'haritanın' oluşturulması. Bu araştırmada alt kategoriler, kategoriler ve kategoriler birleştirilerek oluşturulan olası temalar araştırmacı ve kodlayıcılar tarafından gözden geçirilmiş ve verilerle uyumu kontrol edilmiştir. Kategorilerin tutarlılığı ve olası temaların kategorileri kapsayıp kapsamadığı araştırmacı ve kodlayıcılar tarafından tartışılarak taslak tematik harita oluşturulmuştur. Gözlemler sonucunda oluşturulan aşamalarla ilgili araştırmacı ve kodlayıcılarla yapılan görüşmeler sonucu düzenlenmiş ve aşamalara son şekli verilmiştir.

Temaların tanımlaması ve isimlendirilmesi: Her temaya ait özelliklerin sadeleştirilmesi ve her bir temanın açık bir şekilde tanımlanması ve isimlendirilmesidir. Bu araştırmada araştırmacı tarafından oluşturulan ve isimlendirilen olası temalar tanımlanmış ve temalara diğer kodlayıcılar ile tartışılarak tanımları, isimleri ve içeriği konusunda kesinlik kazandırılmıştır.

Raporun hazırlanması: Somut ve inandırıcı doğrudan alıntı örneklerinin seçilmesi, kodlanan veri içeriklerinin son kez analiz edilmesi, analiz sonuçlarının araştırma sorusu ve alan yazınla tekrar ilişkilendirilmesi, analizin akademik bir dille raporlaştırılmasıdır. Bu araştırmada oluşturulan temalar, temaların altın yer alan kategoriler, alt kategoriler ve kategorileri oluşturan kodlar araştırmacı ve kodlayıcılar tarafından tekrar tartışılarak son hali verilmiştir.

Araştırmanın Etik İzinleri

Araştırmanın etik izni Kütahya Dumlupınar Üniversitesi Etik Kurulu'nun 11/11/2019 tarihli ve 2019/13 toplantı sayılı kararı ve Kütahya İl Milli Eğitim Müdürlüğünden uygulama çalışmasına yönelik izin 53490996-44 sayılı kararla alınmıştır.

Bulgular

Sınıf öğretmeni adaylarının model oluşturma etkinlikleri temelli STEM yaklaşımı uygulamalarının nasıl gerçekleştirdiğine dair ders video kayıtlarının ve uygulayıcı-gözlemci öğretmen adayları ile ilkokul öğrencilerinin süreç ile ilgili görüşlerinin analizi sonucu "İlkokul 4. Sınıf Matematik Dersinde Model Oluşturma Etkinlikleri Temelli STEM Uygulamaları" ve "Model Oluşturma Etkinlikleri Temelli STEM Uygulamalarına İlişkin Görüşler" temaları oluşturulmuştur. Temalar, kategoriler ve alt kategorilere ait sonuçlar aşağıda ayrıntılı olarak açıklanmıştır. Yapılan gözlemler ve görüşmelerin analizi ile elde edilen örnek diyalog veya görüşler ingilizce metinde ifade edildiğinden dolayı genişletilmiş özette ilgili diyalog veya ifadelere yer verilmemiştir.

İlkokul 4. Sınıf Matematik Dersinde Model Oluşturma Etkinlikleri Temelli STEM Uygulamaları

Ders video kayıtları incelendiğinde İlkokul 4. Sınıf Matematik Dersinde Model Oluşturma Etkinlikleri Temelli STEM Uygulamaları teması; "problemin hissedilmesi ve belirlenmesi", "model oluşturma etkinlikleri sürecine geçiş", "matematiksel modelleme süreci", "ürün taslaklarının oluşturulması ve mühendislik tasarım sürecine geçiş", "ürün tasarımının yapılması" ve "ürünlerin sunumu ve değerlendirme" aşamalarını kapsamaktadır. Belirtilen 6 aşama birbiri arasında ileri veya geri geçiş yapılabilecek döngüsel bir süreçten oluşmaktadır. Öğrencilerin grup çalışması yaparak günlük hayat problemini anlamlandırıp matematiksel modelleme yardımıyla çözmesi ile başlayan süreç, mühendislik tasarım sürecine geçiş aşaması ile birlikte ürün tasarlama, tasarladıkları ürünün sunumu ve değerlendirmesi ile tamamlanmaktadır. İlkokul 4. sınıf matematik dersinde model oluşturma etkinlikleri temelli STEM uygulamaları teması, aşamaların sırasına uygun şekilde süreci yansıtacak biçimde aşağıda başlıklar halinde açıklanmaktadır.

Problemin Hissedilmesi ve Belirlenmesi

Ders video kayıtları incelendiğinde model oluşturma etkinlikleri temelli STEM uygulamalarının ilk aşaması günlük hayat probleminin hissedilmesi ve belirlenmesi olarak karşımızda çıkmaktadır. Uygulayıcı öğretmen adayları matematiksel modelleme problemine geçmeden önce öğrenciler tarafından problemin anlaşılması adına öğrencilerin günlük hayatından örnekler vermiş, akıllı tahta kullanarak, gazete ile televizyon haberlerinden örnekler, çizgi filmlerden görseller, videolar veya şarkılar göstermiştir.

Ayrıca katılımcıların görüşleri incelendiğinde Matematik dersi, öğrencilerin ilgisinin olduğu diğer bir disiplinle (fen, sanat, mühendislik vb.) ilişkilendirildiğinde dolaylı olarak

öğrencilerin matematiğe de ilgisinin arttığı anlaşılmaktadır. Aynı zamanda matematiği diğer disiplinlerle ilişkilendirerek günlük hayat problemleri üzerine çözüm üretmeye çalışmak öğrencilerin matematiğin günlük yaşamdaki konumunu anlamlandırmasına da yardımcı olduğu söylenebilir.

Model Oluşturma Etkinlikleri Sürecine Geçiş

Öğrenciler tarafından günlük hayat probleminin hissedildiği ve anlaşıldığı aşamadan sonra öğretmen adayları model oluşturma etkinlikleri sürecine geçiş yapmışlardır. Matematiksel modelleme problemleri öğrencilere bireysel olarak dağıtılmış ve öğrencilerin problemi okuması ve anlaşılmayan noktaları sormaları istenmiştir. Öğrencilere sunulan matematiksel modelleme probleminin hem gözlem hem de etkinlik planları sonuçlarına göre başlangıçta verilen problem durumu ile ilişkili olduğu söylenebilir. Öğretmen adaylarının matematiksel modelleme probleminin anlaşılması için yoğun çaba sarf ettiği gözlemlenmiştir. Model oluşturma etkinlikleri sürecine geçiş aşaması her sınıf öğretmeni adayı için ayrı ayrı incelendiğinde, problemin hissedilmesi ve belirlenmesi aşamalarındaki farklı yaklaşımlardan kaynaklanan durumlar nedeniyle küçük nüanslarla da olsa sürecin farklılık gösterdiği görülmektedir. Her ne kadar model oluşturma etkinliklerinin STEM içerisinde kullanılmasının olumlu yansımaları olsa da model oluşturma etkinliklerini bir etkinlik çerçevesinde STEM kapsamında konuyla ilişkilendirmenin bazı durumlarda öğretmen adaylarını zorladığı görülmektedir.

Matematiksel Modelleme Süreci

Bu aşamada matematiksel modelleme probleminin öğrenciler tarafından iyice anlaşıldığı tespit edildikten sonra öğretmen adaylarının problemin çözümü için öğrencileri yönlendirdiği gözlemlenmiştir. Çözümlerin grup tartışması yapılarak bulunması konusunda öğretmen adaylarının gruplar arasında dolaşarak rehberlik ettiği görülmektedir. Her grubun sorusuna ve ihtiyacına cevap vermeye çabalamışlar ve grup çalışmasına katılmayan veya süreci engelleyen öğrencileri tekrar çözüm sürecine katılmaya teşvik etmeye çalışmışlardır. Daha sonra öğretmen adayları modelleme probleminin öğrenciler tarafından grup çalışmasıyla çözümü sonucu elde ettikleri matematiksel modelin sunumunu istemişlerdir. Genellikle etkinliklerde öğretmen adayları tarafından ilk hafta bu sunumla sonuçlandırılmış ve öğrencilerden ikinci hafta etkinliğin diğer kısmına kadar yapılmasını istediklerini ifade ederek birinci haftayı sonlandırmışlardır.

Ders video kayıt gözlemleri ve hem uygulayıcı-gözlemci sınıf öğretmeni adayları hem de ilkokul 4. sınıf öğrencileri ile yapılan görüşmeler sonucunda ise model oluşturma etkinliklerinin STEM içerisinde belirli bir konu çerçevesinde kullanımının öğrencilerin matematik becerisini geliştirdiği, yapılan uygulamadan daha iyi sonuçlar alındığı, problem çözümünde matematiğin fen, mühendislik gibi alanlara göre ön plana çıktığı, matematiğin somut hale gelmesini sağladığı ifade edilebilir. Ayrıca model oluşturma etkinliklerinin, STEM eğitimi yaklaşımının matematik dersinde kullanılmasında bir yöntem olarak kullanılabileceği söylenebilir.

Ürün Taslaklarının Oluşturulması ve Mühendislik Tasarım Sürecine Geçiş

Ürün taslaklarının oluşturulması ve mühendislik tasarım sürecine geçiş aşamasının ilk boyutunda öğretmen adaylarının öğrencilerden modelleme problemlerinin çözümü olan matematiksel modellerini ve problemin içinde yer alan fen bilimleri dersi kazanımlarını temele alarak tasarlamalarını istedikleri ürünün iki boyutlu taslaklarını oluşturmalarını istediği

görülmüştür. Çoğunlukla matematiksel modellemenin yapılmasının hemen akabinde gerçekleştirilen bu boyutun iki haftalık sürecin ilk haftası içerisinde tamamlandığı anlaşılmaktadır. İkinci hafta ise mühendislik tasarım sürecine tekrar geçiş amacı ile öğretmen adayları tarafından dersin başında modelleme probleminin içinde yer alan fen bilimleri dersi kazanım veya kazanımları tekrar vurgulanmıştır. İlk hafta yapılanlar hatırlatılarak öğrencilerin sürece tekrar dahil olmasına yönelik çabalarda bulunulmuştur.

Ürün Tasarımının Yapılması

Sınıf öğretmeni adayları tarafından ürün taslakları oluşturulduktan sonra öğrencilerden önceki haftadan istenilen malzemeleri kullanarak taslaklarını üç boyutlu model haline getirmeleri istendiği gözlemlenmiştir. Grup çalışması ile yürütülen ürün tasarımının yapılması aşaması öğretmen adaylarının sınıf yönetiminde en çok zorlandığı ve en pasif kaldıkları aşama olarak ortaya çıkmaktadır. Bu aşamada bütün öğretmen adaylarının yaşadığı ortak sorun öğrencilerden istenen malzemelerin eksik getirilmesi ve bunun sonucunda öğretmen adaylarının yaşadıkları problemlerdir. Malzeme eksikliği yaşandığı durumlarda gruplar arası paylaşımlarla veya öğretmen adaylarının önceden düşünerek sınıfa getirdiği malzeme takviyesiyle sorun çözülmeye çalışılmıştır.

Ürünlerin Sunumu ve Değerlendirme

Öğrenciler tasarladıkları ürünleri üç boyutlu model haline getirdikten sonra öğretmen adayları grup içinde seçilen bir sözcü tarafından ürünlerinin sunumunu istemiştir. Öğrenciler modellerini tanıtmışlar, özelliklerini anlatmışlardır ve diğer gruplar tarafından tanıtılan modeller hakkında görüşler alınmıştır. Ürünlerin sunumundan sonra öğretmen adayları sürecin son aşaması olan değerlendirmeye geçmiş, çoğunlukla kâğıt kalem testlerini kullanarak değerlendirme çalışmalarını yapılmışlardır. Ancak burada dikkat çeken nokta değerlendirme çalışmalarına ayrılan sürenin yetersiz olmasından kaynaklanan yetiştirememe problemlerinin yaşanmasıdır. Süre sorunu nedeniyle değerlendirme soruları ya ev ödevi olarak verilmiş ya da öğrenciler tarafından hızlıca tamamlanması istenerek dersin son anlarında toplanmıştır. Sınıf öğretmeni adaylarının ölçme değerlendirme açısından genelde tek bir yönteme bağlı kaldığı, ürün, akran, öz ve süreç değerlendirme açısından eksik kaldığı söylenebilir. Yine başka bir eksik yön de değerlendirmelerin puan olarak bir karşılığının olmamasıdır. Sadece bir öğretmen adayı soruları doğru yanlış olarak değerlendirmiş, ancak bu da öğrencilere puan olarak geri dönüt olarak verilmemiştir. Bu durum öğretmen adaylarının değerlendirme yöntemleri açısından bilgi ve deneyim eksikliğinden kaynaklanmış olabileceği gibi yapılabilecek değerlendirme yöntemlerinin çeşitliliğinin zaman ve uygulanabilirlik açısından zor olmasından da kaynaklanıyor olabilir.

Model Oluşturma Etkinlikleri Temelli STEM Uygulamalarına İlişkin Görüşler

Model Oluşturma Etkinlikleri Temelli STEM Uygulamalarına İlişkin Görüşler teması üç kategori ve dört alt kategoriden oluşmaktadır. Bu kategori ve alt kategoriler yalnızca uygulamayı yapan sınıf öğretmeni adayları ile yapılan yarı yapılandırılmış görüşmeler ve günlük değerlendirmeleri, uygulamayı gözlemleyen sınıf öğretmeni adaylarıyla yapılan görüşmeler ve günlük gözlem raporları ile ilkokul 4. sınıf öğrencilerinin yazılı görüşlerine dayanarak yapılan analiz sonucu elde edilmiştir. Ders video kayıtlarının gözlemleri ile bağdaştırılamayan ve gözlemlerden elde edilemeyen bulguların yer aldığı bu temanın altında “Model Oluşturma

Etkinlikleri Temelli STEM Eğitimi Uygulama Süreci", "Bir Sonraki Etkinlik ve Mesleki Yaşama İlişkin Görüşler" ve "İlkokul Öğrencilerinin Beceri Gelişimine İlişkin Görüşler" isimli üç kategori yer almaktadır. Bunun yanında Model Oluşturma Etkinlikleri Temelli STEM Eğitimi Uygulama Süreci kategorisi "Model Oluşturma Etkinlikleri Temelli STEM Eğitiminin Uygulanabilirliği" ve "Uygulamaya Yardımcı Olan Unsurlar" alt kategorilerinden oluşmaktadır. İlkokul Öğrencilerinin Beceri Gelişimine İlişkin Görüşler kategorisi ise "21. Yüzyıl Becerilerini Kazanma" ve "Diğer Beceriler" alt kategorilerinden oluşmaktadır.

Model Oluşturma Etkinlikleri Temelli STEM Eğitimi Uygulama Süreci

Model oluşturma etkinlikleri temelli STEM eğitimi uygulama süreci kategorisi "model oluşturma etkinlikleri temelli STEM eğitiminin uygulanabilirliği" ve "uygulamaya yardımcı olan unsurlar" alt kategorilerinden oluşmaktadır. Model Oluşturma Etkinlikleri Temelli STEM Eğitiminin Uygulanabilirliği alt kategorisi, kullanılan yaklaşımın ilkokul 4. sınıf matematik dersinde uygulanabilirliğini etkileyen, öğretmen adayının kontrolünün dışında yer alan, uygulamanın yapılıp yapılamayacağını etkileyen genel durumları ifade etmektedir. Bu alt kategorinin kodları "fiziki şartlar", "öğrenci seviyesi", "müfredat durumu", "sosyo-ekonomik düzey" şeklinde belirlenmiştir.

Model oluşturma etkinlikleri temelli STEM eğitimi uygulama süreci kategorisinde uygulamaya yardımcı olan unsurlar alt kategorisi, Model oluşturma etkinlikleri temelli STEM eğitiminin ilkokul 4. sınıf matematik dersinde uygularken sınıf öğretmeni adaylarını ve uygulamayı olumlu yönde etkileyen durumları ifade etmektedir. Bu kategorinin kodları "sınıf öğretmeni desteği", "öğrencileri gruplandırma", "uygun konu seçimi" ve "öğrenci hazırbulunuşluğu" şeklinde belirlenmiştir.

Bir Sonraki Etkinlik ve Mesleki Yaşama İlişkin Görüşler

Bu kategori, sınıf öğretmeni adaylarının model oluşturma etkinlikleri temelli STEM eğitiminin ilkokul 4. sınıf matematik dersinde uygulanması sonucu hem bir sonraki tasarlayacakları ve uygulayacakları etkinlik açısından hem de mesleki yaşamlarında kullanmaları açısından görüşlerinin analizi ile elde edilen bulguları kapsamaktadır. Bu kategorinin kodları "zamanı planlama", "kazanım ve konu seçimi" ve "mesleki yaşamında kullanma" şeklinde belirlenmiştir.

İlkokul Öğrencilerinin Beceri Gelişimine İlişkin Görüşler

Model oluşturma etkinlikleri temelli STEM eğitimi yaklaşımının ilkokul 4. sınıf matematik dersinde uygulaması sürecinde uygulanan etkinliklerin ilkokul öğrencilerinin beceri gelişimine üzerindeki etkileri kategorisi "21. Yüzyıl becerilerini kazanma" ve "Diğer Beceriler" olmak üzere iki alt kategoriden oluşmaktadır. 21. Yüzyıl becerilerini kazanma alt kategorisi model oluşturma etkinlikleri temelli STEM eğitimi yaklaşımının ilkokul 4. sınıf matematik dersinde uygulanması sonucu STEM yaklaşımının hedeflediği temel 21. yy. becerilerinin kazanımının ilkokul dördüncü sınıf öğrencilerinde gözlemlenme durumuna ilişkin bulguları kapsamaktadır. Bu alt kategorinin kodları "iş birliği yapma", "iletişim", "yaratıcılık" ve "eleştirel düşünme" şeklinde belirlenmiştir.

Tartışma ve Sonuç

Öğrenci seviyesi model oluşturma etkinlikleri temelli STEM yaklaşımının uygulanabilirliğini etkileyen faktörlerden biri olarak ortaya çıkmıştır. Öğretmen adayları ilk etkinliklerinde ilkokul 4. sınıf öğrenci seviyesine uygun model oluşturma etkinlikleri temelli STEM yaklaşımına yönelik etkinlik tasarlamakta ve uygulamakta zorlanmışlardır. Ancak diğer etkinliklerde kazandıkları tecrübelerle öğrenci seviyesi konusunda yaşadıkları zorlukları aştıkları ortaya çıkmıştır. Alanyazına bakıldığında benzer şekilde STEM etkinlerinde öğrenci seviyesinin önemli olduğunu, sınıf seviyesi arttıkça STEM disiplinlerinin ilişkilendirilme düzeyinin arttığını ve etkinlikleri uygulamada etkili bir faktör olduğunu belirten araştırmalar bulunmaktadır (Kaya ve Ayar, 2020; Korucu ve Kabak, 2021). Bu doğrultuda katılımcıların ilk etkinliklerinde zorlanması anlam kazanmaktadır. STEM etkinliklerinin uygulandığı sınıflarda başarı artışı, konuyu daha iyi anlama ve kalıcı öğrenme gibi olumlu sonuçları vardır (Acar, Tertemiz ve Taşdemir, 2018; Alumbaugh, 2015; Becker ve Park, 2011; Bolat, 2020; Herdem ve Ünal, 2018; Kanadlı, 2019; Seage ve Türegün, 2020; Siregar, Rosli, Maat ve Capraro, 2020). Bunun yanında Akgündüz ve Akpınar'ın (2018) yaptığı çalışmada okul öncesi eğitimde dahi STEM uygulamalarının öğrencileri hem akademik başarı hem de beceri gelişimi açısından olumlu etkilediği ve Becker ve Park'ın (2011) okul düzeylerine göre STEM yaklaşımının en büyük etki büyüklüğünü ilkokul düzeyinde bulduğu sonuçlarına bakıldığında da ilkokul düzeyinde de STEM eğitimi uygulamaları yapılabileceği düşünülebilir. Bu çalışmada da ilkokul 4.sınıf öğrencileri seviyesinde STEM etkinlikleri uygulanabileceği ve yapılan etkinliklerin öğrenciler üzerinde olumlu katkılar yapabileceği sonuçlarına ulaşılmıştır.

Uygulanabilirliği etkileyen faktörlerden müfredat durumu ile ifade edilen durum, ilkokul matematik ve fen bilimleri dersi ünite, konu ve kazanımlarının model oluşturma etkinlikleri temelli STEM yaklaşımının okullarda gerçekleştirilmesine yönelik kısmen uygun olduğunu kapsamaktadır. Alanyazında bilgiye dayalı sınav sistemi çerçevesinde şekillenen mevcut okul müfredatlarının STEM eğitimi yaklaşımı uygulamalarını sınırlandırdığı sonucuna ulaşılan çalışmalar mevcuttur. Bu sınırların öğrencilerin sınav kaygısından kaynaklandığı ifade edilmiştir (Doğan, 2019; Kanadlı, 2019; Kaya ve Ayar, 2020; Korucu ve Kabak, 2021; Mumcuoğlu Topaloğlu, 2020; Uğraş, 2017). MEB öğretim programlarında Türkiye Yeterlikler Çerçevesi kapsamında öğrencilerden beklenen yeterliklerin STEM'in beklentileriyle çoğunlukla benzeştiği görülmektedir. Ancak MEB (2016) STEM eylem planında öğretim programlarının STEM eğitimini içerecek biçimde güncellenmesi adımı bulunmasına rağmen, ilkokul matematik öğretim programında STEM ile ilgili herhangi bir kazanım veya beceri bulunmamaktadır. Fen bilimleri öğretim programında ise her ünitenin sonunda STEM çalışması yer almakta ve hatta öğrencilerin yaptıkları ürünlerin bilim şenliği adı altında sene sonunda sunulması önerilmektedir. Benzer şekilde matematik öğretim programında da STEM'i entegre edecek şekilde eklemelerin yapılmasının gerekli olduğu söylenebilir. Bu çalışmada elde edilen müfredat durumunun STEM uygulamalarına kısmen uygun olduğu yönündeki bulgularla da bu durum örtüşmektedir.

Katılımcıların görüşlerine göre matematik dersi başka bir disiplin (fen, sanat, mühendislik gibi) veya disiplinlerle ilişkilendirildiğinde öğrencilerin matematiğe olan ilgisinin arttığı söylenebilir. Alanyazına bakıldığında STEM uygulamalarının öğrencilerin bir disiplinin sınırını aşarak disiplinler arası yaklaşımla öğrenmelerine olanak sağladığı görülmektedir (Eroğlu ve

Bektaş, 2016; Kanadlı, 2019; Kaya ve Ayar, 2020; Kopcha vd., 2017; Siew, Amir ve Chong, 2015; Uğraş, 2017). Aynı zamanda STEM eğitiminin disiplinler arası öğretime olanak vermesiyle öğrencilerin yaratıcı düşünme becerilerini olumlu yönde etkilediği (Gülhan ve Şahin, 2018) ve öğretmen adaylarının da disiplinler arası eğitim algıları üzerinde olumlu etkisinin bulunduğunu görmek mümkündür (Herdem ve Ünal, 2018; Korucu ve Kabak, 2021; Yıldırım ve Gelmez-Burakgazi, 2020). Ayrıca öğrencilerin disiplinler arası yaklaşımla sunulan STEM etkinliklerini tercih ettiğinin görüldüğü çalışmalara rastlanmaktadır (Doğan, 2019; Hiğde, 2018). Ancak STEM etkinlikleri kapsamında diğer disiplinlere nazaran matematiğin günlük hayatla ilişkilendirilmesi hususunda zayıf kaldığı (Akgündüz ve Akpınar, 2018), disiplinler arası şekilde tasarlanan matematik dersinin öğrencilerin problem çözme becerilerine anlamlı bir etkisinin olmadığı (Dickerson, Eckhoff, Stewart, Chappell ve Hathcock, 2014; Elliott , Oty, McArthur ve Clark, 2001) ve STEM'i oluşturan disiplinler içerisinde matematiğin diğer disiplinlere göre başarı bağlamında en az etki büyüklüğüne sahip olduğu (Becker ve Park, 2011) çalışmalar da bulunmaktadır. Bu çalışmada katılımcılar tarafından model oluşturma etkinlikleri temelli STEM yaklaşımının uygulanmasının öğrencilerin matematiğe karşı olan ilgilerini arttırdığı yönünde olumlu görüş belirtildiği düşünüldüğünde matematiğin günlük hayatla daha güçlü bir şekilde ilişkilendirilmesi açısından faydalı olabileceği ifade edilebilir.

Matematiği temele alma ve matematik dersi kazanım ve konularının STEM etkinliği içine yerleştirme açısından katılımcılar bağlam entegrasyonu kurmakta zorlandıklarını ifade etmişlerdir. Yapılan gözlemlerde de bazı öğretmen adaylarının bağlam entegrasyonu kurmakta zorluk yaşadıkları görülmektedir. Alanyazına bakıldığında benzer şekilde farklı disiplinleri bir bağlamda birleştirmenin zorluğunu işaret eden çalışmalar görmek mümkündür (Estapa ve Tank, 2017; Firdaus, Wardani, Altaftazani, Kelana ve Rahayu, 2020; Kaya ve Ayar, 2020; Lidinillah, Mulyana, Karlimah ve Hamdu, 2019; Uğraş ve Genç, 2018; Weber, Fox, Levings ve Bouwma-Gearhart, 2013). Bağlam entegrasyonunda zorlanmanın nedenleri arasında ise STEM etkinliklerinin nasıl bütünleştirileceğine dair yeterli bilgiye sahip olmamanın, kaynak ve destek eksikliğinin bulunduğu düşünülebilir (Weber, Fox, Levings ve Bouwma-Gearhart, 2013). Weber, Fox, Levings ve Bouwma-Gearhart'ın (2013) işaret ettiği entegrasyona ilişkin yeterli bilgiye sahip olmama, kaynak ve destek eksikliği gibi durumlar giderildiğinde bağlam entegrasyonununda yaşanan sorunların azalacağı düşünülebilir.

Katılımcılar, STEM'in matematik dersinde uygulanmasında model oluşturma etkinliklerinin uygun bir yöntem olabileceği yönünde görüş belirtmiştir. Konuyla ilgili yapılan çalışmalar da STEM'in matematik başarısında etkili olduğunu (Berk, 2020; Bolat, 2020; Hakim, Sulatri, Mudrikah ve Ahmatika, 2019; Hiğde, 2018; Kim ve Choi, 2012; Prawvichien, Siripun ve Yuenyong, 2018; Siregar, Rosli, Maat ve Capraro, 2019) ve öğrencilerin matematiğe yönelik tutumlarını olumlu yönde etkilediğini göstermektedir (Ching, Yang, Wang, Baek, Swanson ve Chittoori, 2019). Aynı zamanda STEM etkinlileri kapsamında öğrenciler matematik bilgilerini pratikte nasıl uygulayabileceklerini de deneyimlemektedirler (Kopcha vd., 2017; Wieselmann, Roehrig ve Kim, 2020). Doğan, Gürbüz, Çavuş-Erdem ve Şahin (2019) disiplinler arası matematiksel modelleme çerçevesi kullanarak STEM etkinlikleri yapılabileceğini ve bu durumun gerçek dünya problemlerinin çözümünde yaşanılan zorlukların üstesinden gelmek için bir araç olabileceğini ifade etmişlerdir. Doğan'ın (2019) araştırmasına bakıldığında matematiği temele alarak STEM etkinliklerinin uygulanmasının matematik konularını eğlenceli ve daha anlaşılır hale

getirebileceği görülebilmektedir. Diğer disiplinlere nazaran matematiği STEM etkinlikleri içerisine yerleştirmenin zorluğu da aynı zamanda bilinmektedir (Lidinillah, Mulyana, Karlimah ve Hamdu, 2019). Bu çalışmada da katılımcılar STEM etkinliklerinde matematiğin temele alınması noktasında zorluk yaşadıklarını ifade etmişler ancak model oluşturma etkinliklerinin bu zorluğu aşmak için uygun bir yöntem olduğunu belirtmişlerdir.

Katılımcılar etkinlik sonunda ölçme değerlendirme aşamasında genellikle kâğıt kalem testlerini, sunum yaptırmayı ve ürün değerlendirmeyi kullandıklarını ifade etmişlerdir. Akran değerlendirmeyi genellikle ürün sunumu sonrası diğer gruplarda yer alan öğrencilere yorum yaptırarak kullanmışlar ancak değerlendirme formu kullanmadıkları görülmektedir. Öz değerlendirme noktasında ise eksik kaldıkları söylenebilir. Yapılan gözlemler ve katılımcıların etkinlik dosyalarının incelemesi sonucuda benzer bir durum görülmektedir. Alanyazında STEM etkinliklerinde ölçme ve değerlendirmenin önemli bir yere sahip olduğu, bu yolla öğrencilerin performans ve öğrenme düzeylerine yönelik bilgi edinilebileceği ve etkinliklerin bu bilgiler ışığında düzenlenebileceği belirtilmektedir (Pulat, 2020; Zengin, Kaya ve Pektaş, 2020). STEM etkinlikleri kullanılarak gerçekleştirilen çalışmaların büyük bir çoğunluğunda da ölçme ve değerlendirme yapıldığı anlaşılmaktadır. Ölçme ve değerlendirme boyutunda STEM etkinliklerinin değerlendirme aşamasında diğer yöntemlere nazaran sunum yönteminin daha sık kullanılabilmesi (Pulat, 2020) 21. yy. becerileri kapsamında iletişim becerisinin gelişimi için de önemlidir. Bu çalışmada da değerlendirme türleri açısından eksikleri olmasına rağmen katılımcıların kullandıkları değerlendirme çeşitlerinin yeterli sayıda olduğu düşünülebilir.

Model oluşturma etkinlikleri temelli STEM yaklaşımını katılımcıların mesleki yaşamlarında kullanma durumu; etkinlik yapma sıklığı, temele alınacak ders ve motivasyon unsurlarını kapsamaktadır. Etkinliklerin her zaman yapılamayacağını ancak sağladığı faydalar düşünüldüğünde dönemde bir defa da olsa mutlaka yapılması gerektiği ifade edilmiştir. Benzer şekilde öğretmenlerin STEM temelli etkinlikleri çeşitli kriterler göz önünde bulundurarak derste uygulayamadıkları buna karşın ders dışı egzersiz olarak kullandıklarına yönelik bulgulara rastlamak mümkündür (Eroğlu ve Bektaş, 2016). Ancak öğrencilerin gözünden bakıldığında ise bu tür etkinliklerin daha sık uygulanmasının talep edildiği de görülebilmektedir (Doğan, 2019). Hangi sıklıkla kullanılırsa kullanılsın öğretmen adaylarının gelecekte bu tür etkinlikleri kullanmak için çeşitli motivasyonlarının olduğu görülmüştür. Katılımcıların gelecekte bu tür etkinlikleri kullanma konusunda öğrencilerin etkinliklere ilgisinin olması, gerçek yaşamla probleminin çözülmeye çalışılması, öğrenciye temel 21. yy. becerilerini kazandırması ve ders tekrarı olması gibi durumlar motivasyon kaynaklarını oluşturmaktadır. Alanyazına bakıldığında STEM uygulamalarına yönelik öğretmenlerin ve öğretmen adaylarının genellikle olumlu tutum geliştirdiği, mesleki gelişime katkı sağladığının düşünüldüğü görülmektedir (Alumbaugh, 2015; Herdem ve Ünal, 2018; Kaya ve Ayar, 2020; Korucu ve Kabak, 2021; Uğraş, 2017; Uğraş ve Genç, 2018).

Katılımcıların görüşlerine göre model oluşturma etkinlikleri temelli STEM yaklaşımının ilkokul 4. sınıf matematik dersinde uygulanması sonucu STEM yaklaşımının hedeflediği temel 21. yy. becerilerinin (iş birliği yapma, iletişim, yaratıcılık ve eleştirel düşünme) ilkokul dördüncü sınıf öğrencilerinde gözlemlendiği belirlenmiştir. Yapılan pek çok araştırma da bu bulguya benzer şekilde STEM uygulamalarının öğrencilerin 21. yy. becerilerini olumlu yönde etkilediğini

göstermektedir (Akgündüz ve Akpınar, 2018; Hiğde, 2018; Kanadlı, 2019; Kaya ve Ayar, 2020; Korucu ve kabak, 2021; Uğraş, 2017; Uğraş ve Genç, 2018). Ancak bazı araştırmalarda da STEM etkinliklerinin STEM 21. yy. becerileri üzerinde bir etkiye sahip olmadığı da göze çarpmaktadır (Doğan, 2019). Doğan (2019)'ın çalışması ile bu çalışma arasındaki farklılık, iki araştırma arasındaki veri toplama aracı (görüşme- başarı testi), örneklem (öğretmen adayı- yedinci sınıf öğrencisi) ve yöntem (nitel – nicel) farklılıklarından kaynaklanıyor olabilir.

Model oluşturma etkinlikleri temelli STEM yaklaşımının uygulanması sonucu katılımcılar öğrencilerin, ilgi duyma ve motivasyon, soyut düşünme, psikomotor beceriler, uzamsal düşünme, deneyim, verilen zamanı kullanma, grupla çalışma ve matematiksel modelleme konularında olumlu ve olumsuz deneyimler yaşadığını ifade etmişlerdir. Yapılan STEM etkinliklerinin çoğunun; öğrencilerin süreç boyunca kendi kararlarını vermesine, kendi araştırmalarını yapmasına fırsat tanıdığı, anlamlı öğrenmeyi sağlayan güncel öğretim yaklaşımlarıyla beslendiği, kalıcı, etkili öğrenmeyi sağladığı ve temelinde öğrenci merkezli olarak tasarlandığı görülmektedir (Kaya ve Ayar, 2020; Pulat, 2020). Yaparak ve yaşayarak öğrenmenin diğer öğrenme biçimleri arasındaki oranı düşünüldüğünde STEM etkinliklerinin öğrenci için uygun bir öğrenme ortamı sağladığı düşünülebilir.

Katılımcılar model oluşturma etkinlikleri temelli STEM yaklaşımının uygulanması sonucu öğrencilerin, derse ve konuya ilişkin ilgi ve motivasyonlarının arttığını ifade etmişlerdir. Ayrıca bu artışta yapılan uygulamanın öğrencilere diğer derslere göre farklı gelmesinin, uygulama sonucunda ürün oluşturmanın, uygulama sürecinde öğrencinin aktif katılımının ve uygulama sürecinin öğrenciye eğlenceli gelmesinin etkili olduğunu belirtmişlerdir. İlkokul öğrencilerinin de etkinlik yaptıkları derslerin diğer derslere göre daha eğlenceli olduğunu belirten ifadeleri bulunmaktadır. Alanyazında görüldüğü üzere birçok değişkene (cinsiyet, ebeveyn eğitim düzeyi, bilgisayar veya internete sahip olma durumu vb.) bağlı olarak STEM'e yönelik tutumlarda farklılık yaşanabilmesine karşın (Azgın ve Şenler, 2019; Korucu ve Kabak, 2021) genel olarak bu çalışmaya benzer şekilde STEM uygulamalarının öğrencilere eğlenceli geldiğini, öğrenilen konuya yönelik öğrencilerin ilgi ve motivasyonlarını arttırdığını gösteren çalışmalara rastlamak mümkündür (Acar, 2018; Acar, Tertemiz ve Taşdemir, 2018; Afriana, Permanasari ve Fitriani, 2016; Akgündüz ve Akpınar, 2018; Arık ve Benli Özdemir, 2019; Berk, 2020; Bolat, 2020; Ching vd., 2019; Doğan, 2019; Eroğlu ve Bektaş, 2016; Hacıoğlu ve Başpınar, 2020; Kanadlı, 2019; Kaya ve Ayar, 2020; Kopcha vd., 2017; Korucu ve Kabak, 2021; Pekbay, Saka ve Kaptan, 2020; Sarı ve Katrancı, 2020; Siew, Amir ve Chong, 2015; Toma,ve Greca, 2018;Uğraş, 2017; Ültay, Emeksiz ve Durmuş, 2020; Yasak, 2017).