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Examining the Development of Pre-Service Science Teachers' STEM-Focused Lesson Planning Skills*

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ABSTRACT

Purpose: In the 21st century, the importance of the fields of science, mathematics, technology, and engineering, and the need of the skilled individuals have paved a way for a great responsibility on teachers providing instruction in these four fields. Therefore, in this context, it is essential that teachers need to receive education for the cultivation of STEM skills in schools. The present study, it is aimed investigate the development of the STEM-focused lesson planning skills of pre-service science teachers who participated in STEM-focused laboratory activities.

Research Methods: This research was designed as a single case study. The participants in this research study were seven pre-service science teachers. Data were collected through the lesson plans developed by the pre-service science teachers and analyzed using descriptive analysis.

Findings: The results showed that STEM-focused laboratory activities contributed to the development of pre-service science teachers' skills about planning a STEM-focused lesson.

Implications for Research and Practice: The findings suggest that the Science Teaching Laboratory Practices course might be structured with STEM-focused activities to improve the STEM-focused lesson planning skills of pre-service teachers. Providing long-term education to pre-service teachers in person can be recommended for improving their STEM-focused lesson planning skills. In this research, lesson plans of pre-service teachers were examined in terms of content, approach, assessment and evaluation. Development of more detailed analyses is suggested for examining lesson plans.

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Introduction

In recent years, one of the most important reform movements that countries have enacted in education is Science, Technology, Engineering and Mathematics (henceforth referred to as STEM) education with the aim to integrate the disciplines of science, technology, engineering, and mathematics (Bybee, 2010; National Academy of Engineering [NAE] & National Research Council [NRC], 2009; NRC, 2012; Smith & Karr-Kidwell, 2000). STEM education described as finding solutions for the problems through benefiting from the procedures of mathematics and science and integrating teamwork by including process of engineering design and employing appropriate technology at the same time (Shaughnessy, 2013). STEM education includes the unification of at least two STEM fields (e.g., science and mathematics) and the use of knowledge, skills, and beliefs based on the aims of these fields (Corlu, Capraro, & Capraro, 2014; Dugger, 2010; Moore et al., 2014). STEM education allows students to think an integrated manner within the context of science, technology, engineering, and mathematics by confronting them with the situations from daily life and to implement these thoughts in real-life events (Thomas, 2014). Literature shows that the STEM learning environments have significant impacts on student experiences, their career choices, academic success, and the skills, such as advance thinking skills, entrepreneurship, and communication (Fllis & Fouts, 2001; Lou, Shih, Diez, & Tseng, 2011; Tsai, 2007; Wendell et al., 2010).

STEM and Teacher Training

The importance in the 21st century of the fields of science, mathematics, technology, and engineering and the need for individuals to have the skills that this century requires show that a great role has fallen upon teachers who provide instruction in these fields. Preparing STEM-focused lesson plans is undoubtedly important for the teachers who teach in these fields. Therefore, in this context, receiving education for the cultivation of STEM skills in schools for teaching is necessary (Capobianco, 2013; Han, Yalvac, Capraro & Capraro, 2015; Hsu, Purzer, & Cardella, 2011). In fact, teachers themselves carrying out unique contexts that provide students with interdisciplinary integration are valued for successful STEM education. Thus, teachers need to gain experience in integrated instruction during in-service or pre-service education.

Various studies draw attention to the importance of teacher training for STEM education. Siew, Amir, and Chong's (2015) findings showed that teachers could have an awareness of necessary support from the workshops of the STEM professional development in selecting STEM-focused activities that are effective, creative, and project-based to incorporate science in their classrooms. Capobianco (2013) conducted a two-week intensive training program for pre-service and in-service teachers and found that teachers' ability to use the engineering design process in the classroom improved. Han et al. (2015) recommend that teachers should receive STEM training to conduct STEM education based on effective project-based learning. Hsu et al. (2011) suggest that teachers should be more familiar with these concepts, and they need to use professional development programs to increase their motivation to apply these concepts in their lessons. Bozkurt Altan and Ercan (2016) pointed out that STEM-focused training for in-service science teachers improves their STEM-focused course planning competence.

Researchers emphasize the necessity of developing educational content that contributes to the professional development of STEM-focused learning processes. Wilson (2011) points out that the training is provided without the coordination of the institutions that are responsible for teacher education. Thus, pre-service teachers have different efficacy for STEM education. Allen, Webb, and Matthews (2016) draw attention to the importance of having efficacy for STEM education for pre-service teachers. In this context, this study will benefit to the relevant literature by helping researchers develop programs that contribute to the improvement of pre-service teachers' skill of STEM-focused lesson planning and by supporting them to analyze the STEM-focused lesson planning skills.

Pre-service Teacher Training and STEM Education in Turkey

Teaching of science and mathematics disciplines in Turkey is carried out with separate teaching programs. There are no integrated STEM programs in schools or in teacher education programs. Thus, there are courses in science and mathematics disciplines in teacher training programs. The Higher Education Institution determines the general framework of the courses and contents to be taught in pre-service teacher training programs for science and mathematics education programs. In other words, the universities in Turkey generally have the same curriculum and content for pre-service teachers in science or mathematics education programs. Therefore, planning the content to develop teachers' skills for STEM education may contribute to both literature and teacher training programs. Otherwise stated, teacher educators from different universities in Turkey can also use the planned educational content. In the international context, planned activities can be used to improve the skills of pre-service teacher or teachers.

The relevant studies conducted to investigate STEM education in the pre-service teacher education in Turkey show that the published research mainly focuses on the attitudes, opinions, and awareness of the participants about STEM education (see Altun, Yalcin, & Yalcin, 2018; Bakirci & Karisan, 2018; Hacioglu, Yamak, & Kavak, 2017; Kizilay, 2018; Inancli & Timur, 2018). There are also studies about the STEM-focused activities carried out during undergraduate education. These studies examined the potential effects of these activities on various 21st-century skills of pre-service teachers, their attitudes toward STEM practices, and awareness about STEM fields (Bozkurt, 2014; Cetin & Kahyaoglu, 2018; Hacioglu, 2017). Unlike these studies, Ercan (2016) examined pre-service teachers' professional development about STEM education. Also, Gul (2019) planned a STEM Education lesson design that included the content of Instructional Technologies and Material Design and Special Teaching Methods I courses.

Unlike the literature, this study recommended that there would be an intensive process that fits into the nature of the Science Teaching Laboratory Practices course (in science teacher undergraduate program). This study also investigated the potential effects of the active participation of pre-service teachers in certain activities on their skills about STEM-focused lesson planning. To apply the STEM-focused lesson in the classrooms, it is important for pre-service teachers to prepare STEM-focused lesson plans. In this context, it is believed that it might benefit the literature significantly to reveal whether the experience of those pre-service science teachers who have participated in various activities in STEM-focused learning environments help them plan the secondary school science course with a STEM-focused. In this research, we aimed to observe the development of the STEM-focused lesson planning skills of pre-service science teachers who participated in STEM-focused laboratory activities. In line with this aim, an answer is sought to the underlying question of "Do the pre-service science teachers who attend STEM-focused laboratory courses improve their STEM-focused lesson planning skills?"

Method

Research Design

In this research, STEM-focused laboratory activities were developed for the Science Teaching Laboratory Practices (STLP) course in the science teacher education undergraduate program. The aim of the STLP course is to improve pre-service teachers' skills to integrate laboratory activities into science courses. Hence, this course has a content that is suitable for the enrichment of the interdisciplinary perspective, which is the most current innovative learning approach. The activities were conducted in 13 weeks. In this research study, the pre-service science teachers were asked to write a lesson plan that was based on the STEM approach before the STLP course, during the STLP course, and after the STLP course. The pre-service science teachers were expected to write their lesson plans based on the learning outcomes of the middle school science curriculum. In this context, we aimed to investigate whether there was an improvement in the STEM-focused lesson planning skills of pre-service science teachers who participated in STEM-focused laboratory activities.

This study was conducted in the framework of the case study model, a qualitative research technique. Case study is used when researchers want to have a detailed evaluation of a program or the in-depth investigation of an incident (Marshall and Rossman, 2006). In other words, the case study can be defined as the in-depth definition of an entirely limited system (Merriam, 1998).

Participants

This research was carried out in the framework of STEM-focused activities within the STLP course. Thirty-five students were enrolled in one of the two sections of the STLP course. Seven pre-service teachers were selected as participants from these 35 pre-service science teachers on a voluntary basis. Four of the participants were female, and three of them were men from a public university. The participants were in their third year in the science education department. It is thought that the description of the participants' previous experiences on STEM education was beneficial as that experience can affect the plans that pre-service teachers write before the STLP course.

The participants had a four-week STEM training experience at the basic level and examined STEM activities. At the same time, they gained theoretical knowledge of STEM education in the Private Instruction Methods in Science Education I (PIM-I) course. The participants' names were colour coded as follows: Purple, Pink, Yellow, White, Blue, Green, and Orange.

STEM-Focused Activities

The STEM-focused activities that were conducted in the Science Teaching Laboratory Practices course were as follows: Healthy Living, Crime Scene Inspection, Heat Insulation, Animal Design with Legos, Miraculous Institution and Easy Transition with Ardunio.

The "Healthy Living" activity was developed as problem-based learning with STEM education. A problem statement was presented in which the participants were expected to prepare a diet program special to a person. Information about eating habits, physical characteristics, diagnosed diseases, and tests results were provided to this person. Then, the participants were asked to design a mobile application for the diet program. The disciplines of science, technology, and mathematics were integrated into this activity. This activity was administered in four hours (4*40').

In the "Crime Scene Inspection" activity, which was the other activity planned as STEM education through problem-based learning, a forensic crime scene scenario was presented to the pre-service science teachers. The participants conducted various analyses that helped them act like a crime scene expert and analyze the evidence related to the incident by creating a mathematical model regarding foot length and height. The disciplines of science and mathematics were integrated into the activity. The activity was administered in eight hours (8*40').

The "Heat Insulation" activity module was developed by Bozkurt Altan et al. (2016) and was structured on the axis of the engineering design problem. In this case, the participants were expected to select suitable insulation and to define heat insulation materials based on the sixth class material and heat unit learning outcomes. The disciplines of science, technology, engineering and mathematics were integrated into the activity. The activity was conducted in six hours (6*40').

For the "Animal Design with Legos" module, the characteristics (i.e., feeding habits, living space, and a form of respiration) of an unnamed animal were presented to the participants in the context of a problem case. The participants were asked to specify the physical characteristics of this animal, such as utilizing its traits in the problem, guessing which creature was described, and drawing the true dimensions of the creature at ½ scale after identifying its characteristics. Science and mathematics disciplines were in the activity. The activity was administered in six hours (6*40').

For the "Miraculous Institution" activity module structured with the engineering design process, the participants were asked to design a shelter and sailboat with certain materials under desert island conditions. Science, engineering and mathematics disciplines were integrated into the activity. The activity was implemented in eight hours (8*40′).

The final activity was the "Easy Transition with Arduino" module, which was structured around the axis of an engineering design problem. The participants were expected to develop a technological vehicle for the purpose of ensuring the controlled transit of vehicles in an intersection found in the province where they live. The disciplines of science, technology, engineering and mathematics were integrated into the activity. The activity was conducted in 16 hours (16*40′).

Data Collection Tools

The data were derived from the pre-service science teachers' STEM-focused lesson plans. Pre-service teachers were asked to write their lesson plans within the scope of the learning outcomes of the secondary school science course curriculum. In this context, we aimed to evaluate the pre-service teachers' skills that they integrate STEM disciplines into courses and plan science courses within the frame of STEM-focused practices. No restriction was made regarding the format of the lesson plans. Participants had sufficient knowledge about how to write a lesson plan. The pre-service teachers were asked to write STEM-focused lesson plans in groups before the STEM-focus activities and after the STEM-focus activities in the STLP course. They were also asked to write two lesson plans individually during the process of the activities. Table 1 shows the weeks at which the pre-service teachers wrote their lesson plans individually and as a group during a term.

Table 1.

Information about the Schedule of the Lesson Plans Written by the Participants

Participants	**Before STLP Course (Prepared as a Group)**	**During STLP Course (Prepared as a Individual)**		**After STLP Course (Prepared as a Group)**
Purple	1 week ago	At week 6	At week 12	At week 14
Pink	1 week ago	At week 6	At week 8	At week 14
Yellow	1 week ago	At week 6	At week 10	At week 14
Blue	1 week ago	At week 2	At week 6	At week 14
White	1 week ago	At week 1	At week 2	At week 14
Green	1 week ago	At week 3	At week 6	At week 14
Orange	1 week ago	At week 3	At week 6	At week 14

As shown in the Table 1, all the participants wrote the lesson plans one week before the STLP course and one week after the completion of the plans in groups that they conducted the activities with.

Data Analysis

The code scheme by Ercan (2016) was used to analyze the lesson plans. The lesson plans were analyzed and provided feedback based on the categories of contents, approach, assessment, and applicability, found in this code scheme. Table 2 presents the code scheme.

Table 2.

The Code Scheme

Category	Codes	Meaning of Codes
Content	Only science	Only science learning earning objectives are considered.
	Science and other independent discipline	In addition to science, for other STEM disciplines, the learning objectives outcomes are considered, but interdisciplinary connections cannot be mentioned, disciplines are handled separately.
	Other discipline integrated with science	In addition to science, learning objectives for other STEM disciplines are considered, and there are links between field knowledge and practices for disciplines.
	Science and other independent disciplines	In addition to science, learning objectives for multiple STEM disciplines are considered, but interdisciplinary connections cannot be mentioned, disciplines are handled separately.
	Other disciplines integrated with science	In addition to science, learning objectives for multiple STEM disciplines are considered, and there are links between field knowledge and practices for disciplines.
Approach	STEM-focused	Engineering design-based learning Inquiry-based learning Problem-based learning
	STEM Non-focused	Teacher presentation Experimentation
Assessment and evaluation	No content for Assessment and Evaluation	The lesson plan does not have any content about measurement and evaluation.
	Only science content evaluated	Measurement-evaluation was planned only for evaluating the science content e.g., a multiple-choice test for science content only.
	Integrated into STEM fields	Integrated measurement and evaluation for the STEM fields included in the activity (e.g., preparing modelling questions that reflect the integration of science and mathematics into the subject of the food chain).
Applicability	Activity is applicable.	The activity contains related science outcomes. At least two STEM disciplines have been integrated. Compatible with the student's actual life/context. Applicable within the periods mentioned in the Science Curriculum.
	Organized event	The activity does not meet at least one of the four criteria of applicability.

The lesson plans of all of the participants were examined in the analysis process. The reliability of the data analysis was calculated using Miles and Huberman (1994) proposed formula (Reliability of the data analysis=[Same opinions/(Same opinions + Different opinions)]). For the reliability of the data analysis, two researchers' opinions were gathered, and the inter-reliability percentage was calculated as 89%. Then, researchers compared their results of the analysis and interpreted together. To complete the final analysis of the process, an expert who had experience in STEM education examined the latest version of the analysis.

As an example of the results, only one of the participants' (Purple) the lesson plan contents and also analysis were provided. The improvements of other participants' skills concerning STEM-focused lesson planning were commented on throughout the process.

Researchers' Roles and Ethical Considerations

Before the implementation of this study, information about the study steps was given to the participants. The study participants were determined on a voluntary basis. The names in the lesson plans of the participants were kept confidential. The activities that were administered during the study were not physically harmful to students. Both researchers of this study played an active role in carrying out the activities.

Validity and Reliability of this Research

Merriam (2013) explains the validity and reliability of qualitative research in terms of internal validity and external validity and reliability. The concept of internal validity is related to the accuracy of inferences about cause and effect made by the researcher. External validity is related to the extent to which the results of a study can be applied to other situations. Reliability is the availability of the same results when the research is repeated by the same or a different researcher. In this research, the procedures for internal validity, external validity and reliability are as follows: It was checked whether there were any other situations that might affect the development of pre-service science teachers' STEM-focused lesson planning skills. The characteristics of the participants were explained in detail. To ensure the reliability of this research, the process was followed by a second researcher. The process is presented in detail. Data were analyzed by two researchers, and the agreement percent was calculated.

Results

The lesson plans that all the participants wrote individually and as a group before the STLP course, during the STLP course, and after the STLP course were examined. The results were presented below.

Results for the Lesson Plans that Purple Prepared

The results for the lesson plans that Purple wrote individually and as a group before the STLP course and after the STLP course was presented in Table 3.

Table 3.

The Results of Purple's Lesson Plans

Category	Before STLP Course	During STLP Course		After STLP Course
	Group Lesson Plan	Individual lesson plan at week 6	Week 12 Individual Course Plan	Group Course Plan
Content	Only science	Science and engineering discipline integrated	All STEM disciplines integrated	All STEM disciplines integrated
Approach	Teacher presentation Individual study and formal teamwork	Engineering design and scientific research-inquiry Individual study and formal teamwork	Engineering design and scientific research inquiry Individual study and formal teamwork	Engineering design and scientific research-inquiry
Assessment and evaluation	Only intertwined with science-related instruction	Integrated into STEM areas	Integrated into STEM areas	Integrated into STEM areas
Applicability	The event must be organized.	The activity can be applied.	The activity can be applied.	The activity can be applied.

Before the STLP course, Purple prepared the lesson plan together with the group members. In the lesson plan, the activities included solely concepts and contents related to science discipline. The learning outcomes in the middle school sciences course instructional program were aimed. Only multiple-choice questions that included the science-learning outcome for the assessment and evaluation were found in the lesson plan. The lesson plan was aimed at the lesson outcome of "knowing and showing with a drawing that the light emerging from a source follows a unidirectional and linear path" and "classifying the items and providing examples based on the status of light permeability" found in the middle school sciences course instruction program. The instruction process began with the teacher's brainstorming on the topic of light and continued with the "Diffusion of Light" activity for the students to discover the form of diffusion of light at the same environment. Afterwards, they moved to the

"Light Permeability of Materials" activity to identify the light permeability of materials. What learned after the activity was related to daily life, and the students were split up into groups to make periscopes. An activity sheet that included the necessary materials and how to the assembly they were shown to make the periscope was provided to the students. After all the activities, the class concluded with assessment and evaluation activities with multiple choice questions and fill-in-the-blanks to evaluate the learning outcomes of the students.

In the lesson plan prepared individually in the sixth week of the STLP course, Purple discussed environmental problems and wrote a lesson plan in this topic using the engineering design process. The participants structured an instruction process using engineering design process in the context of an engineering problem relating to real-life situations and specified the roles for the individual work and teamwork of the students throughout the instruction process. For the assessment and evaluation of the lesson plan, students played an active role in the instruction process. In this case, various assessment-evaluation activities were emphasized to be integrated with the STEM fields. Purple wrote a lesson plan based on the engineering design process for the learning outcome on the topic of environmental problems in the individually prepared lesson plan. The lesson began by drawing the students' attention to the pollution of the environment. The pre-service teacher distributed activity sheets that included questions for environmental pollution. Purple prepared the sheets for the students to help them research about environmental problems. After dividing the class into groups, scenarios for different environmental issues were distributed to the students, and the groups were asked to create a design using affordable materials that were suitable for the specified environmental issue. In this case, the length of life and durability of the material was observed. The pre-service teacher indicated that adequate time would be provided to the students for the realization of the design and that the evaluation activities would be done based on the grading scale prepared in the scope of the criteria and restraint of the design.

For the lesson plan that Purple prepared individually in the 12th week of the STLP course, the disciplines of science, technology, engineering, and mathematics were included in the instruction process. Purple created a problem situation based on daily life situations to increase students' engagement with the activity. It was clearly stated that the students would be carrying out the work that they perform in teams. The assessment-evaluation of the lesson plan was dealt with in an integrated manner with the STEM disciplines. Purple expected the students to discover the factors that were influential in the formation of seasons in the lesson plan. The lesson began with a remarkable problem sentence describing a child who lived in North America and went to Australia while the season was summer. Afterwards, they moved to the topic regarding the movement of the Earth around the Sun, and the students were asked to show the Earth's movement around the Sun using the Adobe Creative Cloud animation program. Following the animation program, students were asked to create a design that showed the rotation of the Earth with a revolution they created using dynamo. The students were asked to pay attention to the movement of the Earth both around itself and around the Sun and using low-cost to create their design. The assessment evaluation procedure at the end of the activities was composed of evaluations regarding the characteristics expected from the created design.

Purple prepared the final lesson plan together with the group members at the end of the STLP course. The lesson plan for the learning outcome found in the first plan they prepared as a group. Purple planned to conduct the instruction with the engineering design process and inquiry-based learning by correlating the inquiry-engineering disciplines. The pre-service science teachers prepared the lesson plans. They discussed the assessment and evaluation activity integrated with the instruction process that was at an applicable level. Purple and the team members had the students do the "Light Permeability of Materials" activity, so they would have information regarding the permeability of light at the beginning of the instruction process. Afterwards, they moved to the "Undercover Assignment: Line" activity regarding the topic. In this activity, students were asked to make a design that has a light source that helped them see in the dark while underwater, measure underwater pressure, and allowed them to see underground burrows in the Earth. The assessment-evaluation activities took place at the end of the class, with the grading of the created design.

Results for the Lesson Plans that Pink Prepared

Pink planned to conduct the instruction process within the framework of the engineering design process *before the STLP course*. However, the plan had to be reorganized because it did not suit the engineering design due to unspecified criteria and constraints regarding the problem case. *In the sixth week of the STLP* course, Pink planned to administer the engineering design process in the context of a problem relating to real life in the context of environmental issues. For the lesson plan that the Pink prepared *in the eighth week of the STLP* course, Pink planned a STEM-focused lesson by integrating the science and mathematics disciplines. Pink made arrangements in the first prepared lesson plan written with the group members *at the end of the STLP course*. In this respect, they planned a process in the scope of the engineering design process, just like in the first lesson plan. The assessment and evaluation in the plans (prepared 6th, 8th, and 14th weeks) were concentric with the activities, and they were related to the STEM fields. However, the plans can be applied in the science class. Because the activity contains the related science learning outcomes, at least two STEM disciplines should be integrated, compatible with the student's actual life/context and applicable within the periods mentioned in the Science Curriculum.

Results for the Lesson Plans that Yellow Prepared

Before the STLP course, it was determined that Yellow's group wanted to prepare a lesson plan suitable for the engineering design process but that the lesson plan did not reflect the steps of the engineering design process completely. In this context, the lesson plan contents were evaluated as independently from the science and engineering discipline. Yellow prepared the lesson plan contents *in the sixth week of the STLP course* by considering the steps of the engineering design process. Yellow expressly stated the roles of the student and the assessment-evaluation activities and designed a lesson plan that could be implemented in STEM education. Lesson plan prepared individually *in the 10th week of the STLP course* that the Yellow handled with the engineering design process. The assessment and evaluation in the plan were concentric with the activities, and they were connected with the STEM fields. Yellow noted the engineering design process in the lesson plan prepared together with group members *after the STLP course*. The criteria and constraints expected concerning simple machines were specified in the activity prepared, considering the engineering design process. The group members planned the instruction process in accordance with the engineering design process and discussed in an integrated manner with the STEM fields for the assessment and evaluation activities. The plans prepared in the 6th, 10th, and 14th week can be applied in the science class.

Results for the Lesson Plans that White and Blue Prepared

Analysis of the lesson plans that White and Blue prepared as a group was provided together because they were in the same group in the STLP course.

Results for the Lesson Plans that Blue Prepared Individually

The contents of the lesson plan that Blue prepared individually *in the second week of the STLP course* were evaluated in the scope of only the science discipline. The assessment and evaluation activities of the instruction processes, where the student roles were uncertain, were related to only the discipline of science. The lesson plan must be organized. The lesson plan prepared individually *in the sixth week of the STLP course* was designed based on the steps of the engineering design process. The assessment and evaluation activities of the lesson planned to be conducted individually and as a team for the students were related to the instruction process and was aimed at the STEM fields. The plans can be applied in the science class.

Results for the Lesson Plans White Prepared Individually during the STLP Course

The lesson plan prepared by White in *the first week of the STLP course* was not suitable for STEM education. At the same time, the assessment evaluation activities were designed to be related to only the science discipline. The lesson plan must be organized. White designed a second lesson plan, which was prepared individually *in the sixth week of the STLP course*, by correlating the science and technology disciplines. The plans can be applied in the science class. For the lesson plan that White provided included detailed information for the team-work of the students and dealt in an integrated manner with the process of the assessment and evaluation activities.

Results for the Lesson Plans that Blue and White Prepared as a Group before and after the STLP course

Blue and White aimed to design the lesson plan according to the engineering design process as a group *before the STLP course*. However, they planned the lesson plan in the scope of only the discipline of science. Because they organized activities only relating to science in the assessment and evaluation activities, the prepared instruction plan should be reorganized in the framework of STEM instruction. In the lesson plan that they prepared as a group *at the end of the STLP course*, they included the disciplines of science and mathematics in the integrated process. The assessment and evaluation activities were designed in an integrated manner with the STEM fields in the instruction plan, where the roles of the student were expressed clearly. The plans can be applied in the science class.

Results for the Lesson Plans that Green Prepared

Green designed a lesson plan with only science contents for the lesson plan prepared *before the STLP course* together with group members. In this plan, Green planned to administer assessment-evaluation activities within the instruction process regarding sciences. Green organized the instruction process by utilizing technological practices in the lesson plan prepared in the *third week of the STLP course*. The activity contents were evaluated for only science because it was only used for discovering the content of concepts. The lesson plan must be organized. In this lesson plan, results-oriented tests, including science learning outcome, were used as measurement and evaluation. Green wrote the second lesson plan, prepared individually *in the sixth week of the STLP course* based on the engineering design process. In this context, the participant expressly stated the roles of the students and the steps of the engineering design process in the prepared lesson plan. Green planned an integrated measurement and evaluation activity, including the STEM fields. In the lesson plan that Green prepared together with the group members *after the STLP course* in the framework of the topic of chemical reactions, technology was utilized, but the contents of the lesson plan were evaluated solely as a science because they did not structure the process in the context of a problem case. The instruction process continues with the other activities carried out in the scope of the science discipline and concludes with the evaluation activities regarding only science.

Result for the Lesson Plans that Orange Prepared

Orange designed a lesson plan that had only science content together with the group members *before the STLP course*. At the same time, assessment-evaluation activities comprised multiple-choice questions regarding only science. Orange aimed to capture the students' attention by utilizing technological applications for the lesson plan prepared individually *in the third week of the STLP course*. The lesson plan content was evaluated as only science because the participant planned to use only technology supported mobile application. Orange prepared plans with only science content as the process-based assessment evaluation activities. The activity should be reorganized within the framework of the STEM-focused activities. It was observed that Orange's lesson plan prepared individually *in the sixth week of the STLP course* was consistent with the steps of the engineering design process. Assessment evaluation activities in the lesson plan were handled in an integrated manner for the STEM fields. For the final lesson plan prepared together with group members *at the end of the STLP course*, Orange designed a lesson plan in the framework of the steps of the engineering design process. In the plan, the roles of the students and the activities to be carried out were clearly stated. Also, the assessment and evaluation activities were conducted as multiple-choice questions to be used for the purpose of measuring the scientific knowledge of students and in an integrated manner with regard to the STEM fields.

Discussion, Conclusion and Recommendations

In this study, participants were asked to prepare STEM lesson plans individually and as a group before the STLP course, during STLP course, and after STLP course for the purpose of determining their skills about STEM-focused lesson planning.

The results showed that the STEM-focused STLP course generally contributed to the development of the skills of participants concerning STEM education in this study. It was determined in the lesson plans that participants prepared before the STLP course and after the STLP course as a group that they showed development in the categories of "contents", "approach", "assessment and evaluation", and "applicability". Especially, the plans prepared in the sixth week were found to be more competent than the plans prepared in the previous weeks regarding these categories. Various studies also support this conclusion. For example, Bracey, Brooks, Marlette and Locke (2013) organized an intense STEM educational program and determined that the program contributed to the improvement of efficacy and beliefs of pre-service teachers with regard to STEM education. Bozkurt Altan and Ercan (2016) implemented an intense in-service teacher training program in STEM education for science teachers and stated that the teachers developed skills on the topic of instruction process planning for STEM education. Ercan (2016) planned a 14-week instruction process with theoretical and practical contents and noted that this process supported pre-service science teachers' development of skills regarding STEM education.

The content of lesson plans that were prepared individually during the STLP course was suitable for STEM education. All of the participants struggled on the topic of integrating the STEM disciplines into the lesson because of the learning outcome they selected. However, they mentioned about the activities that included the STEM disciplines in their lesson plans. The lesson plans of the four participants were evaluated as they should be and reorganized in the category of "applicability." It was seen that the other three participants prepared lesson plans by suitable integration of the STEM disciplines into course contents during the STLP process, which was seen in the lesson plans that the participants prepared that there was an improvement in the scope of the categories of "contents", "approach", "assessment and evaluation", and "applicability".

Even though the participants of this study had the theoretical background regarding STEM education, it was observed that the lesson plans prepared by pre-service teachers during the entire process improved in the following weeks because the plans became STEM-focused only beginning from the 6th week. This result suggests that it is important for pre-service teachers to actively participate in activities in addition to theoretical education. From another perspective, it can be said that long-term programs can contribute to the development of the skills of pre-service teachers. In a study conducted with science teachers, Bozkurt Altan and Hacioglu (2018) provided a 30-hour education and then analyzed problem cases that they created for implementing STEM-focused activities in their courses. The researchers found that the problem cases of teachers had to be improved, and attention was drawn to that long-term education is necessary for teachers to gain STEM-focused instruction planning skills (Bracey et al., 2013; Capobianco, 2013; Nadelson et al., 2013).

It can be interpreted that this situation originates from the participants having encountered many examples of the engineering design process. Indeed, STEM education is handled in different dimensions. Engineering design process is one of the ways to implement STEM education (Hmelo, Holton, & Kolodner, 2000; Kelley & Knowles, 2016; Moore et al., 2014; NAE & NRC, 2009; Siew, 2017). Throughout the process, various dimensions of STEM education were discussed in STLP course, and STEM was applied with participants for the science lessons. Multiple activities were conducted by the participants concerning the means of realizing STEM education, and they were given the opportunity to implement the lesson. This situation provided to enhance the experiences of the participants regarding the implementation of engineering design along with the experiencing achievement regarding the other STEM-focused applications. Bracey et al. (2013) similarly identified that planning classes regarding STEM education contributed to participants’ interests and development of efficacy regarding STEM education. In addition to this, Bracey et al. (2013), Bozkurt Altan and Ercan (2016), Ercan (2016), who researched the development of efficacy by teachers for STEM education, found an improvement of efficacy after intense or extensive education. Similarly, Capobianco (2013) conducted a two-week intensive training program for pre-service and in-service teachers and found that teachers' ability to understand the engineering design process and use them in classroom applications had improved. Moreover, Allen et al. (2016) found that in-service training for teachers contributed to the development of pedagogical content knowledge about STEM education. In the study by Hacioglu et al. (2017) pre-service science teachers specified that they would give space to STEM-focused activities in future classes in the context of engineering design-based science education activities. A similar situation is also the point in question in this study. It can be considered that the process, which was both intense regarding the class time and extensive over a term, contributed positively to the development of efficacy. Indeed, the lesson plans before the STEM-focused STLP course, during the STEM-focused STLP course, and after the STEM-focused STLP course showed towards the end that development emerged better. Sungur, Gul, and Marulcu (2014) provided short-term education to science teachers to realize STEM education in the context of the engineering design approach. Researchers determined that science teachers had fundamental knowledge regarding the engineering design product but that they were unable to develop efficacy on the topic of using the engineering design process to teach scientific concepts. Similarly, Afarah (2011) gave a seminar over three days to science and mathematics teachers using engineering for teaching the other STEM disciplines. The researcher determined that the interest of teachers increased, but perceptions of efficacy did not develop. This situation reveals the importance of the education of instructors spread out over a process.

The STEM-focused activities administered in a 13-week process for the Science Education undergraduate program STLP course were effective in the development of skills aimed to plan STEM-focused lesson. It can be suggested that the STLP course might be structured with a STEM-focused approach to improve the STEM-focused lesson planning skills of pre-service teachers. Providing long-term education to pre-service teachers in person can be recommended for improving their STEM-focused lesson planning skills.

In this research, lesson plans of pre-service teachers were examined regarding content, approach, assessment and evaluation. Development of more detailed analyses is suggested for examining lesson plans.

The activities developed for the STLP course within the scope of this research can be used by researchers to conduct and improve similar studies with different groups. Finally, it could be suggested that the similar process could be followed to investigate the application skills of pre-service science teachers for middle school students when the pre-service science teachers enrolled Teaching Practice course at the same time with the STLP course.

The limitation of this research is as follows. The findings of this study are limited to the lesson plans of pre-service science teachers. No other data were collected to determine the lesson planning skills of pre-service teachers. However, lesson plans were analyzed thoroughly.

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Fen Bilimleri Öğretmen Adaylarının STEM Odaklı Ders Planlama Becerilerinin Gelişiminin İncelenmesi

Atıf:

Bozkurt Altan, E., & Ucuncuoglu, I. (2019). Examining the development of pre-service science teachers' STEM-focused lesson planning skills. *Eurasian Journal of Educational Sciences, 83, 103-124,* DOI: 10.14689/ejer.2019.83.5

Özet

Problem Durumu: STEM (Fen, Tenoloji, Mühendislik ve Matematik) kısaltması dispilinlerin entegrasyonuna dayanan bir yaklaşımı temsil etmektedir. Bu yaklaşım, öğrenenleri günlük yaşamdan problem durumları ile karşı karşıya bırakarak, fen, teknoloji, mühendislik ve matematik alanları çerçevesinde bütüncül olarak düşünmelerini, çözüm üretmenlerini ve çözümlerini uygulamalarını ön plana çıkarmaktadır (Dugger, 2010; Moore et al., 2014; Thomas, 2014; Fllis & Fouts, 2001; Lou et al., 2011). Dünya'da ve Türkiye'de STEM eğitimine verilen önem değerlendirildiğinde disiplinlerin entegrasyonu sağlayacak özgün bağlamlar geliştirebilecek öğretmenlerin hizmet içi ya da hizmet öncesinde STEM odaklı öğrenme sürecini planlayabilme becerisi kazanmalarının gerekliliği aşikardır. Bu bağlamda STEM odaklı öğrenme ortamlarında etkinliklere katılarak deneyim sahibi olan fen bilimleri öğretmen adaylarının bu deneyimlerinin ortaokul fen bilimleri dersini STEM odaklı anlayışla planlayabilmelerine katkı sağlayıp sağlamadığının ortaya konulmasının alan yazınına önemli katkı sağlayacağı düşünülmektedir.

Araştırmanın Amacı: Bu araştırmada STEM odaklı etkinlikler ile yürütülen Fen Öğretimi Laboratuvar Uygulamaları dersine katılan fen bilimleri öğretmen adaylarının STEM odaklı ders planlama becerilerinin gelişiminin incelenmesi amaçlanmaktadır.

Araştırmanın Yöntemi: Araştırma nitel araştırma desenlerinden durum çalışması esas alınarak yürütülmüştür. Araştırmanın çalışma grubunu, 7 fen bilimleri öğretmen adayı (4 kadın, 3 erkek) oluşturmaktadır. Öğretmen adaylarının isimleri renkler ile kodlanmıştır: Beyaz, Mavi, Turuncu, Yeşil, Pembe, Sarı, Mor. Öğretmen adaylarının Fen Öğretimi Laboratuvar Uygulamaları II dersinden önce hazırladıkları planlarda etkili olabileceği düşünüldüğünden katılımcıların STEM eğitimi konusundaki önceki deneyimlerini betimlemekte fayda görülmektedir. Çalışma grubunu oluşturan öğretmen adayları Fen Öğretimi Laboratuvar Uygulamaları I dersi kapsamında temel düzeyde 4 haftalık STEM eğitimi almış ve STEM etkinlikleri incelemişlerdir. Aynı zamanda Özel Öğretim Yöntemleri I (ÖÖY- I) dersinde STEM eğitimine yönelik teorik olarak bilgi sahibi olmuşlardır. Araştırmanın yürütüldüğü Fen Öğretimi Laboratuvar Uygulamaları II dersini, iki ayrı gruptaki toplam 35 öğretmen adayı almaktadır. Araştırmanın katılımcılarını dersi alan öğretmen adaylarından gönüllü olarak katılım sağlayayan öğretmen adayları olmuştur. Ders, 13 hafta boyunca her hafta 4 ders saati olmak üzere yürütülmüştür. Uygulama sürecinde 5'i araştırmacılar, 1'i Bozkurt Altan, vd. (2016) tarafından geliştirilen toplam altı farklı STEM odaklı etkinlik kullanılmıştır. STEM odaklı etkinlik modülleri probleme dayalı STEM uygulamaları ve mühendislik tasarım süreci esas alınarak planlanmıştır.

Araştırmada öğretmen adaylarının STEM odaklı etkinlik planlama becerilerine yönelik veriler ders planları ile toplanmıştır. Öğretmen adaylarından STEM odaklı uygulamaların öncesinde ve sonrasında grup çalışması ile uygulama sürecinde ise bireysel olarak ortaokul fen bilimleri dersi öğretim programında yer alan kazanımlar kapsamında STEM eğitimine uygun ders planları hazırlamaları istenmiştir. Ders planları betimsel analiz ile çözümlenmiştir.

Araştırmanın Bulguları: Fen bilimleri öğretmen adaylarının STEM odaklı etkinlik planlama becerilerine ilişkin bulgulara göre STEM odaklı etkinliklere katılmanın genel olarak öğretmen adaylarının STEM odaklı ders planlama becerisinin gelişimine katkı sağladığı tespit edilmiştir. Çalışma grubunda yer alan 7 öğretmen adayının STEM odaklı laboratuvar etkinlikleri boyunca hazırladıkları ders planlarında "içerik", "yaklaşım", "ölçme değerlendirme" ve "uygulanabilirlik" kategorileri kapsamında gelişim gösterdikleri tespit edilmiştir.

Öğretmen adaylarının uygulama öncesinde grup olarak hazırladıkları ders planında "içerik" kategorisinde çoğunlukla yalnızca fen disiplinine yer verdikleri ve öğretim sürecini fen disiplini kapsamında planladıkları tespit edilmiştir. Buna bağlı olarak diğer kategorilerde de fen disiplini çerçevesinde etkinliklere yer vermişlerdir. Uygulama sonrasında hazırladıkları öğretim planlarında ise daha çok mühendislik tasarım odaklı ve teknoloji destekli etkinliklere yer verdikleri belirlenmiştir. Öğretmen adayları uygulama sonrası hazırladıkları ders planlarında "ölçme değerlendirme", "yaklaşım" ve "uygulanabilirlik" kategorileri bağlamında da STEM odaklı öğrenme sürecine uygun planlar hazırlamışlardır.

Öğretmen adaylarının uygulama sürecinde bireysel olarak hazırladıkları iki farklı ders planlanında STEM odaklı öğrenme sürecine uygun içeriklere yer verdikleri tespit edilmiştir. 7 öğretmen adayından 4'ü seçtikleri kazanımlar nedeniyle STEM disiplinlerini plana entegre etme konusunda zorluk yaşamış fakat ders planlarında STEM disiplinlerini içeren etkinliklere yer verebilmiştir. Dört öğretmen adayının bireysel olarak hazırladıkları ilk ders planları "uygulanabilirlik" kategorisinde tekrar düzenlenmelidir olarak değerlendirilmiştir. Diğer üç öğretmen adayının ise uygulama sürecinde hazırladıkları iki planda da STEM disiplinlerini ders içeriğine uygun şekilde entegre ederek ders planlarını hazırladıkları tespit edilmiştir. Öğretmen adayları hazırladıkları ders planlarında "içerik", "yaklaşım", "ölçme değerlendirme" ve "uygulanabilirlik" kategorileri kapsamında gelişim göstermiştir.

Araştırmanın Sonucu ve Öneriler: Fen Bilgisi Öğretmenliği lisans programı Fen Öğretimi Laboratuvar Uygulamaları II dersi için 13 haftalık bir süreç içinde gerçekleştirilen uygulamalar öğretmen adaylarının STEM odaklı ders planlamaya yönelik becerilerinin gelişiminde etkili olmuş ve öğretmen adayları süreç içerisinde hazırladıkları ders planlarına bu durumu yansıtmışlarıdır. Öğretmen adaylarının uygulama öncesinde teorik bilgiye sahip olmasına karşın hazırladıkları planların STEM odaklı öğrenme sürecine dair unsurlar içermediği tespit edilmiştir. Kendilerinin STEM odaklı etkinlikler içerisinde yer almaları STEM odaklı etkinlik planlama becerilerinin gelişiminde etkili olmuştur. Bu araştırmanın katılımcılarının STEM eğitimi konusunda teorik alt yapıya sahip olmasına rağmen öğretmen adaylarının süreç boyunca hazırladıkları ders planlarında 6. haftadan itibaren hazırlanan planların STEM odaklı olması bakımından gelişme göstermeye başladığı daha ileriki haftalarda iyileştiği görülmektedir. Bu sonuç teorik eğitimlerin yanı sıra öğretmen adaylarının kendilerinin etkinliklere aktif katılım sağlamasının önemli olduğu biçiminde değerlendirilebilir. Bir diğer yönü ile uzun soluklu programların öğretmen adaylarının becerilerinin gelişimine destek sağladığı söylenebilir.

Öğretmen adaylarına STEM eğitim anlayışını benimseyecekleri öğrenme ortamı oluşturmak üzere Fen Öğretimi Laboratuvar Uygulamaları II dersinin STEM odaklı öğrenme sürecini esas alarak yapılandırılması önerilebilir. Bu araştırmada öğretmen adaylarının ders planları içerik, yaklaşım, ölçme-değerlendirme ve uygulanabilirlik boyutları ile incelenmiştir. Öğretmen adaylarının ders planlarının incelenmesi için daha detaylı çözümlemeler geliştirilmesi önerilebilir.

Anahtar Kavramlar: fen bilimleri öğretmen adayları, STEM, STEM odaklı laboratuvar etkinlikleri, öğretmenlerin becerileri, öğretmen yeterlikleri