Physics pre-service teachers' views on STEM activities*

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Abstract

The goal of this project is to analyze the views of pre-service physics teachers on STEM education and STEM activities. For this purpose, qualitative approach and semi structured interview forms were used as data collection tools. The interview forms were analyzed using content analysis technique. The participants of the study are eight students from Van Yuzuncu Yil University, Faculty of Education, Department of Physics Education. They conducted a research project as part of

'Research Project in Field Education' course and organized a science festival that included six STEM activities for twenty secondary school students. To illustrate the views of pre-service teachers' on STEM activities, the data were obtained from structured interview forms and then qualitatively analyzed. The results indicate that pre-service teachers think that STEM activities were fun, more permanent, more perceptible and more remarkable, and provide active participation. They also indicated that most of them did not have any difficulties in planning and implementing STEM activities and their motivation in the process increased positively. The participants also stated that they would like to use STEM activities in their classes in the future. Pre-service teachers' perceptions, attitudes and opinions about teaching methods and in-class activities may determine the methods and activities they will use in their own classes in the future. Determining the views of pre-service teachers' on STEM activities may therefore affect the studies on STEM education.

Keywords: STEM education, STEM activities, Pre-service Teachers, Research Project in Field Education (RPFE)

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Introduction

The United States National Research Council [NRC] (2011) states that technology production of the twenty-first century's economy is driven by science, mathematics, engineering and technology. The number of students trained with a qualified education in these areas is therefore important for a strong and sustainable economy. Educational programmers and researchers are therefore working on new projects related to science and mathematics to establish a program which will educate the students to create the technological innovations necessary for continuation of the economic developments in the future (Fan and Ritz, 2014). One of such projects is called STEM education and it has being implemented in education system of many countries, especially in the USA. The name of STEM education is an abbreviation for Science, Technology, Engineering and Mathematics respectively (Dugger, 2010).

STEM education is a technology/engineering based learning approach integrating the concepts and practice of science and mathematics with technology and engineering (Sanders & Wells, 2006). According to Fan and Ritz (2014), STEM education can be explained as focusing on each single STEM subject with new teaching methods or integration of science, technology, engineering, and mathematics into curriculum. The aim of integrated STEM education is to enable students to construct new knowledge and improve their problem-solving skills in the design process (Fortus, Krajcikb, Dershimerb, Marx & Mamlok-Naamand, 2005).

The general purpose of STEM education is to increase the number of students in STEM related fields by integrating science, technology, engineering and mathematics into in-class and out-of-school activities from kindergarten through university (Dugger, 2010; Gonzalez & Kuenzi, 2012). STEM activities enable students to easily apply their knowledge to solve technical problems like those seen in real life and provide high level of thinking skills (Dugger, 2010; Sanders, 2009; Zuga 2007). According to Morrison (2006), integrated STEM education makes individuals better in problem solving, innovation, creativity, logical thinking, technology literacy and, most importantly, guide them to have the skills necessary for the twenty-first century. In this context, STEM education enables students to be selected for qualified workforce and can contribute to production of innovative technology.

The results of the Trends in International Mathematics and Science Study [TIMSS] and the Programme for International Student Assessment [PISA] should carefully be consulted to better understand the quality of education in science and mathematics in Turkey and to properly compare education system in Turkey with those of other countries. Turkey's average point in science is 425 while it is 465 for all countries. The average point in mathematics is 420 while it is 461 for all countries. The difference between Turkey's points and the average point for all countries both in science and in mathematics is statistically significant. Turkey's average points in mathematics and science have always been below the average for the OECD countries, and the significant difference mentioned above has remained stable over the years (PISA, 2016).

According to TIMSS 2015 mathematics assessment at the 8th grade level, Turkey was ranked 24th among 39 countries with an average scale score of 458 which was

below the TIMSS scale centerpoint. In TIMSS survey, there are four international benchmarks, i.e. advanced, high, intermediate and low. Among 8th grade students participated in TIMSS 2015 only 6% of Turkish students were able to reach the advanced benchmark in mathematic assessment. Turkey was ranked 21st among 39 countries with an average scale score of 493 (again below the TIMSS scale centerpoint) in TIMSS 2015 science assessment. Only 8% of the 8th grade students from Turkey were able to reach the advanced benchmark in science assessment (TIMSS, 2016).

From Turkey's scores in both PISA and TIMSS assessments, it is seen that the quality of education in the fields of science and mathematics in Turkey is not satisfactory. The lack of achievement is also seen in national exams, such as the Higher Education Transition Examination [HETE] and the Undergraduate Placement Examination [UPE] organized by the Student Selection and Placement Center [SSPC]. In HETE 2016, while the average net score in science test was 4.70 over 40 questions, the average score in basic mathematics was 7.89 over 40 questions. In the 2016 UPE exam, the average net scores in physics, chemistry and biology, each consists of 30 questions, were 5.03, 9.53 and 7.73 respectively, while the average score in mathematics was 9.85 over 50 questions (SSPC, 2016a; 2016b).

The lack of achievement among students in science and mathematics in both national and international exams negatively affects the number of students studying in STEM areas in universities. A new education program is therefore needed to motivate students in the field of mathematics and science. This could improve their achievements in both science and mathematics and encourage them to study in STEM related fields. STEM education will meet this need by providing a qualified workforce, which can keep up with technological developments and make Turkey's economy more competitive and innovative. The Ministry of National Education (MoNE) is well aware of the importance of STEM education. The ministry has already carried out a forecasting study for STEM education in Turkey following the Vision 2023 Project (Serbest, 2005; Çorlu, Capraro & Capraro, 2014). In addition, STEM education took place in pilot schools in Kayseri in 2013 under the management of Kayseri Provincial Directorate of National Education. Organizing national robotics competitions and creating STEM centers in universities clearly indicate that investments in STEM education are increasing in Turkey.

Turkey considers STEM education seriously since it will surely increase the competitiveness of the country in global arena (Çorlu, Capraro & Capraro, 2014). However, to enhance the quality of education, teachers, who are practitioners of teaching programs, should get familiar with interdisciplinary approach during university and gain the necessary skills for STEM education. Çorlu (2014) states that teachers who graduated from integrated teacher education programs will better understand and teach STEM education. On that note, STEM education or integrated education can be included in the curriculum, in courses such as Special Teaching Methods, Material Development, and Research Project in Field Education [RPFE]. Bybee (2011) states that, teachers can teach science and engineering practices with clear and continuous activities without significant changes to the curriculum. In order to be able to provide qualified education in science and mathematics, pre-service teachers should be allowed to participate in STEM studies, so that they may use STEM activities in their own classes in the future regardless of any changes in curriculum. In fact, curriculums published by MoNE in Turkey let teachers to adapt the teaching methods and activities according to circumstances in the school. Pre-service teachers with enough experience in STEM education may therefore use STEM activities during their classes. It is therefore crucial to determine the views of pre-service teachers' on STEM education that has a potential to impact the studies on STEM education. Pre-service teachers' perceptions, attitudes and opinions about teaching methods and in-class activities may affect the methods and activities that they will use in their own classes in the future.

Purpose of the Study

The aim of this study is to investigate the opinions of pre-service teachers who had experiences in STEM education during their Research Project in Field Education (RPFE) course. To address the aim of the study, the following research questions were considered:

1. Were pre-service teachers' expectations compatible with studies conducted within the scope of RPFE course?
2. What do pre-service teachers think about how STEM activities affect their motivation?
3. What are the opinions of the pre-service teachers regarding STEM activities in general?

4. What are the opinions of the pre-service teachers regarding preparing STEM activities?
5. Do pre-service teachers think of using STEM activities in their classes in the future?

Method

Content analysis method is used in educational researches to answer various questions about thinking and learning by considering individual differences (Çepni, 2014). In this study, we used the same method to determine the views of pre-service teachers on STEM activities. The coding technique was used to determine and interpret data obtained from participants in an inductive way (Çepni, 2014).

Participants

The participants of this study were eight pre-service teachers, 3 women and 5 men, who took RPFE course during spring term of 2015-2016. All participants were senior students from Van Yuzuncu Yil University [YYU], Faculty of Education, Department of Physics Education and their ages range from 25 to 30. The participants have not taken any STEM related courses and had no information about STEM education or STEM activities prior to study.

Implementation

The aim of the RPFE course is to enable pre-service teachers to conduct a research in field education. In the scope of the course, students conduct a project on a specific subject related to their field education in the RPFE. Through the project study, they learn research methods, data collection tools, data analysis, and how to illustrate the results. It is important that the research should consist of up-to-date teaching or learning methods and approaches. It was therefore decided to conduct a group study in a project related to STEM education for pre-service teachers in the scope of the RPFE course.

In the scope of the course, during the first month of the term, pre-service teachers conducted research and investigation on STEM education. During lecture hours, extensive discussions were held by the participants on STEM education and STEM

activities. As a result, it was decided to organize a 'Science Festival' including STEM activities for middle school students. On the following month of the term, STEM activities were explored and the participants proposed some activities for the festival. Finally, six hands-on STEM activities were decided to be used in the festival. These activities were *Spaghetti Bridge, Steamy Ship, Art Bot, Fruit Battery, Let's Make an Eye, Coding Hour with Angry Bird.* The 'Science Festival' took place in the faculty of education of YYU, and 20 voluntary students from the nearest middle school were attended to the festival. The festival was started at 9:00 am and ended in 05:00 pm, so took 8 hours in total.

Data Collection Tools and Data Analysis

The structured interview form was used to collect the data. The main purpose of a structured interview is to identify the differences, similarities or contradictions between the information provided by the participants and to compare the findings (Çepni, 2014). The form developed for the interview included five open-ended questions. Two specialists in science education applied the validity test for the study. Interview forms were then given to participants only after all studies in the scope of the course have done.

Content analysis method was used for analyzing the data. The similarities and differences between the information obtained from the answers of pre-service teachers' for each question were examined. In the answers given to each question, appropriate themes were determined for the purpose of the research and the frequencies of repetition of the codes in the themes were examined. The participants were encoded as PT1, PT2…PT8.

Results

In this section, the results obtained from the research questions and the answers of the pre-service teachers were listed.

The compatibility of pre-service teachers' expectations with studies conducted within RPFE

The codes related to pre-service teachers' expectations with studies conducted within RPFE course are presented in Table I.

Table I. Pre-service teachers' expectations and studies conducted within RPFE

Code	Frequency	Pre-service teacher
Doing a research about physics education	8	PT1, PT2, PT3, PT4, PT5, PT6, PT7, PT8
Exactly compatible with my expectations	6	PT1, PT2, PT3, PT5, PT6, PT7
Beyond my expectations	2	PT8, PT4

Pre-service teachers stated that they had expectations of doing a research about physics education, and conducting a project. Besides doing a research they were pleased to implement a new education method. As seen from Table I, while six participants stated that the studies conducted in the scope of the course were exactly compatible with their expectations, two participants stated that the studies were beyond their expectations. Consequently, the STEM education project conducted in the scope of the course is mostly compatible with participants' expectations. Some answers of participants are given below:

PT5: *"I thought we were going to study on a simple project at the beginning of the course. But, after research and discussions we decided to organize a festival. And so, the project course met my expectations."*

PT6: *"I thought to bring a good product out. I was expecting something like that at the end of the process."*

PT8: *"I thought that we were going to do a research about how we could make physics more loveable. The project we conducted was beyond my expectation."*

The Effects of STEM Activities on Pre-service Teachers' Motivations

The codes related to participants' motivation during preparing STEM activities are presented in Table II.

Table II. Pre-service teachers' motivation during the course process

Code	Frequency	Pre-service Teacher

It motivated us in a good way	5	PT4, PT5, PT6, PT7, PT8
It was an enjoyable process	2	PT1, PT2
It was a very good process	1	PT3

As seen from Table II, five participants stated that STEM activities motivated them in a good way in their studies. While two of them stated that it was an enjoyable process, only one participant stated that it was a very good process. The views of some participants' are given below:

PT7: *"It motivated me in a positive way. Especially, my interest to course rose. It was good to do and present something."*

PT4: *"It was really motivated us and relaxed us. It was not like ordinary lessons; the learning environment was like a game place."*

Opinions of Pre-service Teachers' on STEM Activities

In this subsection, the results related to the views of the pre-service teachers' on STEM education and STEM activities are given. The codes related to their views are presented in Table III.

Table III. Pre-service teachers' views about STEM education and STEM activities

Codes	Frequency	Pre-service Teacher
Making lessons more understandable	6	PT2, PT3, PT1, PT7, PT5, PT8
Making lessons more fun	5	PT2, PT3, PT8, PT5
Making lessons more remarkable	3	PT3, PT2, PT6
Providing permanent learning	4	PT4, PT6, PT8, PT7
Providing more perceptible lessons	2	PT5, PT6
Encouraging active participation	5	PT1, PT2, PT5, PT6, PT7
Providing discoveries during learning	3	PT1, PT4, PT6
Being interdisciplinary approach	3	PT2, PT4, PT5

As seen in Table 3, the most repeated codes by participants are 'more understandable (6)', 'fun (6)', 'more permanent learning (6)', 'active participation (5)', and

'remarkable (5)', 'discovery learning (3)', 'interdisciplinary approach (3)', and 'more perceptible (2)'. Some views of participants are given below:

PT4: *"I think there are more advantages of STEM activities than other learning approaches. It provides more permanent learning for students."*

PT2: *"Lessons using STEM activities are more remarkable. I think that it provides more participation."*

PT6: *"Students learnt by doing and living. I think that it provides more permanent learning. The activities we used were fun and more remarkable."*

PT5: *"Activities were fun, perceptible and enjoyable. We can learn subjects from different fields with STEM activities."*

PT7: *"I can say that it provides more permanent learning."*

Pre-service Teachers' Views about Preparing STEM Activities

The codes related to preparing STEM activities are presented in Table IV.

Table IV. Pre-service teachers' views about preparing STEM activities

Code	Frequency	Pre-service Teacher
Concern for success	2	PT2, PT8
No any challenge	5	PT1, PT3, PT4, PT6, PT7
Not be able to dominate each activity	1	PT5

As seen in Table IV, five participants stated that they did not have any challenges; two participants stated that they had concern for success; and one participant stated that it was hard to be able to dominate every activity. Thus, it can be said that participants did not have any challenges during preparing STEM activities. Some views of participants are given below:

PT1 & PT6: *"I was not forced."*

PT4: *"I did not have any challenges. The activities were quite understandable and easy."*

PT7: *"The activities did not force me."*

PT2: *"I had no idea what we were going to do in the first place, but I was worrying about how to accomplish this job."*

PT5: *"Working for activities to be more understandable, and not being dominant on each activity forced me. To come over these challenges one should frequently prepare and implement STEM activities."*

Pre-Service Teachers' Willingness for Implementing STEM Activities in Their Future Classes

The related codes related to participants willingness for implementing STEM activities in their future classes are presented in Table V.

Table V. Participants' willingness for implementing STEM activities in the future and their reason to do so.

Code	Frequency	Pre-service Teacher
I want to implement	8	PT1, PT2, PT3, PT4, PT5, PT6, PT7, PT8
Provides more permanent learning	3	PT1, PT6, PT7
Provides active participation	1	PT2,
More understandable	3	PT3, PT5, PT6
Fun	5	PT3, PT4, PT5, PT6, PT8

All participants are willing to implement STEM activities in their future classes. They pointed out some advantages of STEM activities such as providing more permanent learning and active participation, and making lessons more understandable and fun. Some participants' views are given below:

PT5: *"I absolutely want to implement them. The reason is that activities are more remarkable to students and they are more understandable."*

PT2: *"Yes, I want. STEM activities increase participation and improve sense of production."*

PT1: *"Yes, I want. Learning by doing and inquiring will be more permanent."*

PT8: *"I want to use STEM activities as far as possible. Because, I think lessons will be fun for both teachers and students."*

Conclusion and Discussion

Our study shows that pre-service teachers have positive opinions about STEM education and STEM activities. Participants stated that the project conducted within the scope of the RPFE course was appropriate with the goals of the course, and they were pleased to study in a STEM project (see Table 1). The reason may be that doing research to learn a new learning approach related their field, and organizing a science festival to experience it. Çifçili (2011) concluded that the number of studies in field education conducted by students of physics, chemistry and mathematics education were insufficient. Whereas, pre-service teachers conducting projects in fields of education may provide qualified education in their classes. In fact, Cengiz and Karataş (2014) argue that the RPFE and the Teaching Practice courses should be carried out together and the action research method should be used in order for the pre-service teachers to realize that they can use the knowledge and skills they have gained in the RPFE course.

The participants stated that it was highly motivating to conduct a project related to STEM education within the scope of RPFE course (see Table 2). Besides, some participants stated that it was fun and very good. Experiencing STEM education for the first time and organizing a science festival at the end of the project could be the most important source of their motivations. Additionally, the high motivations of pre-service teachers during the science festival may have caused STEM activities to have consequences in support of students. Because motivations of teachers influence student motivation, and motivated teachers are the guarantee of educational reforms with their willingness (Jesus and Lens 2004). In this context, pre-service and in service teachers need to know and experience STEM activities to ensure STEM education can be transformed into a reform movement in schools.

The views of pre-service teachers about STEM activities were analyzed based on the most frequently repeated codes. The results indicate that the most frequently repeated codes in different questions are 'fun (6)', 'permanent learning (6)', 'understandable (6)', 'active participation (5)' and 'remarkable (4)'. However, the least frequently repeated codes are 'discovery learning (3)', 'interdisciplinary (3)' and 'perceptible

(2)' (see Table 3). In this context, participants believe that STEM activities are fun, more permanent, more perceptible and more remarkable, and provide active participation. The results are compatible with some studies done in Turkey. Ö zçakir-Sümen & Çalışıcı (2016) concludes that STEM activities make lectures more efficient and provides more participation. Altan, Yamak & Kırıkkaya (2016) stated that STEM activities are motivating, fun and providing permanent learning. In addition, Barcelona (2014) stated that STEM activities increase students' academic achievements and provide a good learning practice.

The results also show that most of the participants did not have any difficulties in doing research, providing materials and guideline for each activity (see Table 4). Our results also indicate that while two participants had anxiety of success, one participant had difficulty in dominating all activities. Working together in a group may have been the cause for not having difficulties or easily overcoming the challenges they faced. It can therefore be said that teachers with experiences in STEM activities during their university education can easily overcome the difficulties they faced over time. For this reason, teachers should be willing to use STEM activities in their classes and to do a research and share issues about STEM activities. All participants indeed stated that they would like to use STEM activities in their future classes (see Table 5). Özçakır-Sümen & Çalışıcı (2016) also found the same result. All participants in their study stated that they would like to use STEM activities in their future classes similar to the result of our study. It can therefore be said that teachers with knowledge and experience in STEM activities will possibly use STEM in their classes without expecting curriculum alteration. Applying STEM methods in class will increase students' success in science and mathematics. Indeed, studies in Turkey indicate that STEM activities enhance the students' achievements and encourage them to study and build a career in STEM related fields in the future (Ceylan, 2014; Yamak, Bulut & Dündar, 2014; Baran, Bilici & Mesutoğlu, 2016; Gülhan & Şahin, 2016; Özçakır-Sümen & Çalışıcı, 2016).

Since teachers have a key role in implementing new methods and activities in their classes, it is crucial for teachers to gain experiences in preparing and implementing such activities during their undergraduate. As our study already indicated, we therefore strongly suggest conducting STEM activities in RPFE, teaching practice and special teaching methods courses.

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