Investigate the Evaluations of Prospective Teacher on STEM Education, Based on Their Experiences with Planning and Implementing STEM Activities

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ABSTRACT

This study intends to investigate the evaluations of prospective teachers on STEM education, based on their experiences with planning and implementing STEM activities. The research's study group, designed qualitatively, is composed of 18 prospective teachers who graduated from the department of mathematics, 16 prospective teachers who graduated from the department of chemistry, 9 prospective teachers who graduated from the department of physics engineering and one prospective teacher from the department of textile engineering. STEM education programs carried out within the scope of the research lasted for 12 weeks, with four hours per week. Prior to the training programs, it was determined whether the prospective teachers had previous knowledge of STEM. After six weeks of training, study groups were formed which were composed of prospective teachers from different branches. Each study group performed what they thought was an STEM activity. A structured interview was undertaken with the teams following completion of the activities. The content analysis method was used to analyze the data gathered from the interviews. As a result of the research, it was determined that the applicability of the activity, compliance with the disciplines of STEM, being instructive and the features of the learning outcome are the selecting criteria in determining STEM activities applied. Prospective teachers mentioned a few problems they encountered during the activities. İt was found that the participants thought to implement STEM activities in their professional lteacing routes, but some participants had reservations about the preparation stage and İn this context, the most obvious drawbacks about the preparation phase of the activities are the material supplementation and the preliminary preparation of the activities. The drawbacks regarding the implementation process were caused by concerns such as time consuming activities, in efficient implementation of STEM activities, lack of cooperation between students, lack of active participation of students and a lack of materials.

Keywords: STEM education, Planning and implementing STEM Activities, Prospective teachers

INTRODUCTION

STEM (Science, Technology, Engineering, Mathematics) education has gained importance in many countries in recent years in order to keep up with innovations in a constantly changing world and to raise forward-thinking individuals that can respond to the requirements of the age. STEM education aims to develop high-level thinking skills in students by focusing on at least one of the disciplines of science, technology, engineering and mathematics, and associating the focused discipline or disciplines with other STEM disciplines. (Smith & Karr-Kidwell, 2000; Berlin & Lee, 2005; Apedoe, Reynolds, Ellefson & Schunn, 2008; Chen, 2009; Moore, Stohlmann, Wang, Moore, Roehrig & Park, 2011; Wang, Tank & Roehrig, 2013). İn doing so, the objective is to enable students to use different disciplines in conjunction with each other, increase their interest in future potential careers and support their development in line with the needs of the country (National Research Council, 2011; Gonzalez & Kuenzi, 2012; Zollman, 2012). Another objective of STEM education is to improve students' ability to provide realistic solutions to real life problems through the implementation of active learning and teaching approaches (Kennedy & Odell, 2014), and by encouraging students to use their knowledge of STEM disciplines through a holistic approach (Bybee, 2010; Corlu, 2012; STEM Task Force Report, 2014; Voutour, 2014).

STEM education has strategic importance for a country to maintain its competitiveness on an international scale (Corlu, Capraro & Capraro, 2014). Because STEM is considered as a fashionable trend, but rather a necessity to raise highly skilled people with a say in science and technology. There is a need for innovative brains who have learnt different disciplines in an integrated manner through STEM education. However, it is clear that there are some obstacles to the successful implementation of this kind of education. Among these obstacles include a lack of qualified STEM teachers, a lack of investment in the professional development of teachers, a lack of inspiring environments for teachers, a lack of support by schools, a lack of collaborative research on STEM areas, imperfections with the methods for presenting content and student assessment, and a lack of practical teaching of students (Ejiwale, 2013). İn addition to this lack of resources in schools particularly with respect to engineering discipline of STEM (Roehrig, Moore, Wang & Park, 2012) (Roehrig, Moore, Wang and Park, 2012) and negative teacher attitudes towards STEM trainings due to the time constraints of STEM disciplines (Asghar, Elington, Rice, Johnson and Prime, 2012) Lee and Strobel, 2012), can also be considered as other obstacles.

STEM education’s primary focus is on integrated teaching of different disciplines rather than developing materials or producing learning outcomes (Hernandez Bodin, Elliott, İbrahim, Rambo-Hernandez, Chen & Miranda,2014; STEM Task Force Report, 2014; Hacioglu, Yamak & Kavak, 2018). However, the current corpus of literature on STEM also perpetuates some misconceptions. Some of these misconceptions are: STEM education can only be delivered through Lego and toys, STEM education is only applicable to Physics courses, STEM is only suitable for exceptionally talented children, STEM requires working with expensive equipment, only science experiments, coding or maker activities count as STEM (Yildirim &Selvi, 2016; Akgunduz & Akpinar, 2018). STEM education, on the other hand, should not be seen as making students assemble sets of expensive parts, writing codes in blocks, moving a vehicle with these codes, or switching on/off a led bulb (Aygen, 2018). On the basis of all these considerations, teachers should be qualified in the teaching of the integrated disciplines for proper STEM education, have the necessary pedagogical training and have the self-confidence that they can make this happen (Corlu, 2012). İn this context, study groups were formed from prospective teachers after a professional development training program on STEM. The groups were asked to develop or choose a STEM activity and implement it. An answer was sought to the following research question after the activities were completed:

- What are prospective teachers’ evaluations of planning and implementation processes for STEM activities?

In this context, prospective teachers’ evaluations of planning and implementation processes for STEM activities were examined. Evaluation is, the intent in doing so was to find out what made the participants choose certain STEM activities over others, learn the process of obtaining materials and equipment for the activities, shed light on the challenges with carrying out the activities and gather opinions on the applicability of STEM activities.

When current scientific research in the field of STEM education is examined, it is seen that studies are mostly focused on determining the effects of the components of STEM education such as attitudes (Gulhan & Sahin, 2016; Karakaya & Avgin, 2016), scale adaptation / development (Buyruk & Korkmaz, 2016; Koyunlu Unlu, Dokme & Unlu, 2016; Yildirim &Selvi, 2015), integrated teaching (English, 2017), engineering design and applications' impact on students' academic achievement (Yildirim & Selvi, 2017). On the other hand, there are also studies that look at STEM practices from the point of view of teachers, prospective teachers (Judson & Sawada, 2000; Capobianco, 2011; Cavas, Bulut, Halbrook & Rannikmae, 2013; Cinar, Pirasa & Sadoglu, 2016; Hacioglu, Aygen, 2018; Kutlu & Bakirci, 2018; Ozbilen, 2018; Tekerek & Karakaya, 2018; Thibaut , Knipprath, Dehaene & Depaepe, 2018b; Du, Liu, Johnson, Sondergeld, Bolshakova & Moore, 2019) and students (Gulhan & Sahin, 2016; Pekbay, 2017), where their contributions to students developing 21st century skills are examined (Moomaw & Davis, 2010; Hacioglu, Yamak & Kavak, 2016; Akgunduz & Akpinar, 2018).

The necessity of interdisciplinary approaches and collaborative work in consideration of new challenges posed by the 21st century requires the design of learning environments where students can conduct STEM research from an early age. The need for qualified teachers to run those environments is also obvious (Brophy, Klein, Portsmore & Rogers, 2008; Corlu, 2012; Stolhmann, Moore & Roehrig, 2012; Eijawale, 2013; Guzey, Tank, Wang, Roehrig & Moore, 2014; O'brien, Karsnitz, Sandt, Bottemley & Parry, 2014; Deghaidy & Mansour, 2015; Mcdonald, 2016; Ozbilen, 2018; Lee, Hsu & Chang, 2019). İn this regard, the examination of prospective teachers' evaluations concerning the planning and implementation of STEM activities will help increase awareness on STEM implementations and contribute to the literature in the field.

RESEARCH METHOD

Research Model

This study, in which evaluations of prospective teachers about STEM activity planning and implementation experiences were examined, designed as a qualitative research. İn this context, participants without any previous knowledge of STEM education were educated before being asked to plan and implement STEM activities. After completion of the activities, structured interviews were undertaken using the Assessment Form for the Planning and İmplementation of STEM Activities to assess prospective teachers' views of their own STEM activity planning and implementation processes and their opinions on STEM education overall.

Participants

The study was conducted with 29 female and 15 male prospective teachers receiving the special education methods course offered within the scope of pedagogical training, at an education faculty. Of these prospective teachers, 18 graduated from the faculty of mathematics, 16 from the department of chemistry, 9 from the department of physics engineering, and 1 graduated from the department of textile engineering.

Collection of Data

The study data was collected before and after a 12 week training program (6 weeks STEM lectures, 6 weeks implementation of STEM activities) that was delivered 4 hours per week. Prior to the training program, the participants were asked whether any of them had any previous knowledge of STEM education. The participants, who responded that they did not, were then asked what each of the letters in the word STEM represented and none of them gave the correct answer. İt was therefore established that the participants had no prior knowledge of the concept of STEM or STEM education itself. Afterwards, the participants were provided training over the internet on the content and fundamentals of STEM education for the first six weeks whereby they found the chance to watch videos of sample STEM activities and review lots of academic studies on the topic. The weekly distribution of the contents of the trainings is given in Table 1.

Table 1. The content of STEM Training

Week	Content
1	Content of STEM trainings and philosophy of STEM

2	General information on STEM approach in education
3	Study on the academic studies on STEM education
4	Study on the STEM activities in STEM education teacher handbook (MEB- YEGİTEK, 2018)
5	Examination of recorded STEM activities on WEB
6	İmplementation of a STEM activity (Activity Name: Robotic Hand)

Afterwards, the prospective teachers were asked to prepare and implement STEM activities in a classroom environment over a period of six weeks. Considering that prospective teachers represented different STEM disciplines on the basis of their BA education from different departments, each group was designed to contain at least three participants. Nine groups were formed, where each group contained at least one graduate of mathematics, one graduate of physics engineering and one graduate of chemistry. And in one group, a graduate of physics engineering was replaced by a graduate of textile engineering, making the total number of groups to be 10.

Following a six week training program, each group was asked to choose, prepare and implement an STEM activity. İn this context participants are asked to follow given steps:

- A maximum of 70 minutes was allowed for each activity.
- The groups were firstly asked to prepare the materials required for the activities.
- The teacher groups designed the activities as a group study for students.
- The number of participants in each group was determined on the basis of the adequacy of materials.
- Participants were briefed about the expected final product and evaluation criteria.

One activity carried out within this context is illustrated in Figure 1.

DRAWBRİDGE ACTİVİTY

Objective: Build a Drawbridge
Materials: Spaghetti, Adhesive, tape, scissors
Number of participants: Groups of four
Duration: 60 min.
İnstructions:

1) We would like you to build a drawbridge with the materials at hand.
2) The Assessment criteria for the drawbridge are as follows:
   -Durability 50% (maximum weight carried)
   - Aesthetic design 30% (relative evaluation of the products by participants)
   -**S**uitability of use of material 20% (relative evaluation of the products by participants)

Figure 1 STEM activity for building a drawbridge

As illustrated in Figure 1, instructions were provided on the purpose of the activity, the materials to be used, the duration and what is expected of the participants. Performance assessment was conducted on the basis of the products presented by each group following each activity (Figure 2) and the criteria set out in the activity plan. For instance, concerning the building of a drawbridge, durability had a 50% impact, appearance had a 30% impact and the materials used had a 20% impact.

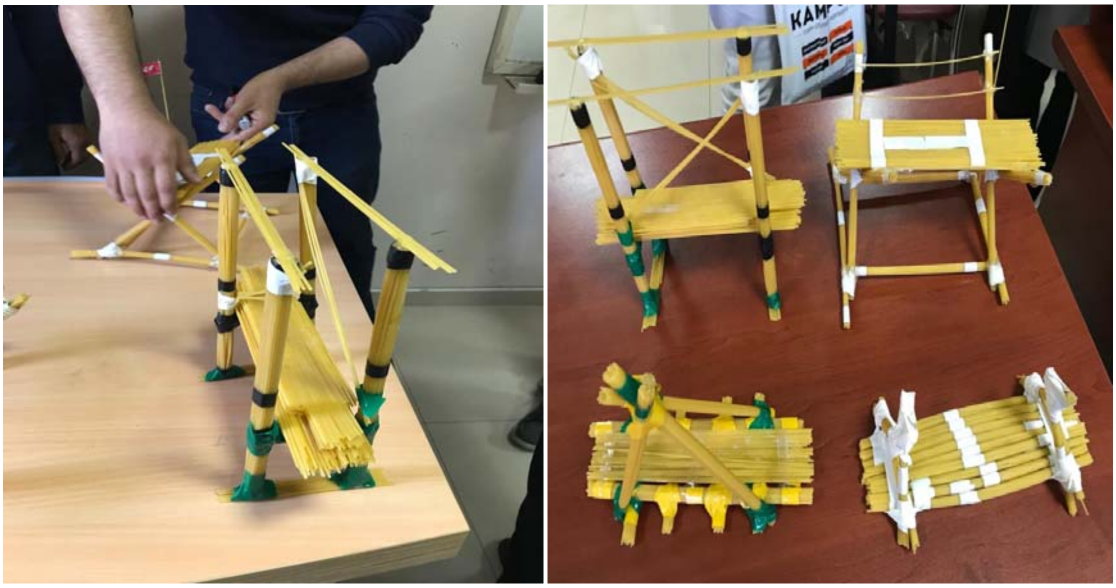

Figure 2. Drawbridge activity products

The groups had no limitations imposed for the STEM activities. But, all activities chosen allowed the used of waste or concrete materials. Following each activity, a structured interview was held with the group conducting the activity using the Assessment Form for the Planning and İmplementation of STEM Activities. The Assesment form developed by researchers and for reliability studies of the form. The form was examined by a field expert within the scope of validity studies. İt was also examined by a linguist in the context of language validity. The form was made ready for implementation after feedback.The following questions were asked at the interview:

1. Why have you chosen this activity within the scope of STEM training? How did you develop it? How did you obtain the tools and materials?
2. How would you assess the implementation process of your activity? Do you believe you have fulfilled the objectives? Did you experience any challenges during the implementation process? İf yes, at what stages?
3. What are your overall views on the applicability of STEM education?
4. Would you consider integrating STEM activities into your teaching routine when you become a teacher? Why?

The activities carried out by the participants were assessed on the basis of their suitability for cooperation, the integration of different disciplines and the varieties of end products. 9 out of 10 activities fulfilling these criteria were assessed as STEM activities. Only one activity was not considered as such. İn the activity where participants were asked to create a square out of two rectangular paper tapes, the participants were expected to create circles out of the tapes, stick them to each other and create a hollow square after cutting through them with scissors, starting from an appropriate point. This activity was not considered as a STEM activity considering that there was only one solution for the activity and it only entailed the use of mathematics as a discipline.

Data Analysis

The content analysis method was used to analyze the data garnered from the interviews. Content analysis is the analysis of data by creating codes or categories (Robson, 2001). Within the scope of content analysis, the responses given by the participants to the question of why they considered the activity they chose as a STEM activity, were first analyzed. The obtained categories, codes and sample responses related to these codes are given in Table 2.

Table 2. Analyses related to the reasons why the participants chose certain STEM activities over others

Category	Code	Sample answers
Compliance with STEM disciplines	Compliance with the objectives of STEM	*We thought building a drawbridge was the most fitting activity for STEM, and so we decided to go through with it (drawbridge).*
	İnclusion of all STEM disciplines	*Because it contains elements of Math, Science, Engineering and Technology (Design).. (the fastest going car)*
	İmportance of the activity content	*Time is one of the most important concepts in our lives and is precious (hourglass).*
	İnclusion of the STEM disciplines of Math and Sci.	*Combining science and math gave us this activity (*Electroscope activity)
	Expert advice	*We decided to carry out this activity with the assistance of a friend studying at the department of Teaching Science. (*Electroscope)
	İnclusion of the STEM disciplines of Math and Engineering	*We chose this particular STEM activity as we believe it does contain aspects of engineering and math* (Hydraulic Lift).
	İnclusion of the STEM disciplines of Math, Engineering and Science	*We chose this activity because it contains elements of Math, Science, Engineering and Technology (Design) (the fastest going car).*
Applicability	Low-cost	*We procured the materials easily from the market as they were simple and cheap (drawbridge activity).*
	Easy application	*İt is the kind of activity that can be conducted easily in favorable circumstances (car made from fruit).*
	Accessibility of materials	*We made sure that the materials were easy to obtain (hourglass).*
	Simplicity	*We chose this activity as it is simple, practical and understandable (the fastest car activity).*
	Duration of activity	*We preferred this activity to other available options as it took much less time to complete (*electromagnet).
	Easy to understand	*We chose this activity as it is simple, practical and understandable (the fastest car activity).*
	Beneficial	*We found lots of other activities but they had no purpose, so we stuck to this one (*electroscope).
Learning	Educational potential	*İt is an instructive activity on the non-compressible nature of liquids* (Hydraulic Lift).
	Provides permanent learning	*Teaching students permanently without them needing to memorize information (car made from fruit).*
	Offers ease of learning	*We have chosen this activity because it is easier to learn and is more effective in terms of learnability (car made from fruit).*
	Provides effective learning	*We have chosen this activity because it is easier to learn and is more effective in terms of learnability (car made from fruit).*
	Delivering new products	*We have chosen this activity to create a new product (electromagnet).*
Product properties	Allows product variety	*The product variety at the end and advantageous designs in each are a serious achievement (hydraulic lift) .*
	Product aesthetics	*An activity with potential for students to bring forth an aesthetically appealing product (car from fruit).*

As seen in Table 2, results obtained from the analyses related to the reasons why the participants chose certain STEM activities over others were gathered under four categories with 21 codes.

The categories, codes and sample responses related to these codes obtained from the responses of the participants to the second interview question are given in Table 3.

Table 3. Challenges faced by prospective teachers when carrying out STEM activities

Category	Code	*Sample answers*
Planning	Challenges with obtaining certain materials	*We had difficulties with finding certain materials but we obtained them all at the end with support from other groups (catapult).*
İntroduction	Ambiguity of instructions	*We realized that some had trouble with understanding some of the activities (electromagnet).*
	Not knowing the working principles of the end product	*İnitially, the groups asked questions about how hydraulic elevators work (hydraulic lift).*
Process	Lack of manual skills	*We noticed that some did not have the required level of dexterity for the activity (electromagnet).*
	Not being able to piece together a piece of wood	*İ had difficulties with piecing together pieces of wood (catapult).*
	Not being able to decide on the flexibility of the rubber (difficulties with adjustment).	*İ had difficulties with adjusting the flexibility of the rubber (catapult).*
Product	Product aesthetics	*We could not bring forth an aesthetically appealing product (electromagnet).*
	Not accepting the emergence of an end product different from what was anticipated	*We initially found it hard to accept that products different to those we expected were coming out of the process (car from fruit).*

As seen in Table 3, challenges faced by the participants when carrying out the STEM activities were gathered under four categories with eight codes.

The categories, codes and sample responses related to these codes obtained from the participants' responses to the third interview question are given in Table 4.

Table 4. Participant opinions concerning the contributions of STEM activities to the learning process

Category	Code	Sample answers
Teaching process	İnstructive	*İnstructive in terms of using and developing simple tools (electromagnet).*
	Fun	*The activity was quite fun (drawbridge).*
	Attention-grabbing	*Students found it interesting (rowboat)*
	Puts concepts on a concrete basis	*Suitable for concretized teaching (electroscope).*
	Smooth teaching process	*the teaching process was smooth and satisfying (drawbridge).*
Learning	Supports permanent learning	*To make it more memorable.. (catapult).*
	Supports learning	*...İ believe it is going to be very beneficial (hydraulic lift).*
	Producer	*İ observed them trying out different methods than the usual ones (hourglass).*
	Facilitates learning	*We have seen how it facilitates learning (hourglass).*
	Reinforces learning	*Can be used to reinforce what is being taught (hourglass).*
Learning process	Creative application	*Activity that develops the creative side of children (hourglass).*
	Helps with self-development	*Highly effective activity that improves children's learning skills (hourglass).*
	Active participation	*As it makes students more active and sociable ..(catapult)*
	Teamwork	*İt was useful activity that teaches teamwork and races against time (catapult).*
	Problem solving	*İt teaches students problem-solving skills (electromagnet).*
	İmproves manual skills	*The activity will help promote students' manual skills among other things (the fastest car).*
	Promotes scientific inquiry	*Students learn through discovery (rowboat).*
	İnquisitive	*STEM raises the inquisitive and curious minds of the future (car from fruit).*

As seen in Table 4, participants' views on the contributions of the STEM activities to the learning process were gathered under three categories with eighteen codes.

The categories, codes and sample responses related to these codes obtained from participants' responses to the fourth interview question are given in Table 5.

Table 5. Misgivings of participants about the applicability of STEM activities

Category	Code	Sample answers
Preparation process	Difficulties with obtaining/accessing materials	*Can be applied at all times so long as the tools and materials can be obtained (catapult).*
	Requires planning and preparation	*İt requires being prepared in advance (catapult).*
	High costs	*Lack of resources may make obtaining materials more difficult (hourglass).*
	Time-consuming	*İ think annual plans must be prepared accordingly as they take too much time (rowboat).*
	Lack of cooperation between teachers and students	*Teachers need to cooperate with students' parents (electroscope).*
Application process	Failure to ensure the active participation of students	*İt should be ensured students take active part in the activities (hydraulic lift).*
	Eagerness to do better overshadows learning	*Obsessing about being the winner should not preclude learning (catapult).*
	Takes too much effort	*… it is time-consuming and labor-intensive as opposed to that (car from fruit).*

The misgivings of participants about the applicability of STEM activities were gathered under two categories with eight codes.

Reliability of the Study

To ensure reliability, the continuous comparative data analysis method was used in the analysis of data from each research question. Continuous comparative data analysis includes the coding of examined data in inductive categories and the continuous comparison of the data being examined (Ekiz, 2003). The reliability of the analyzes was ensured by two academicians through a full compliance of the codes within the framework of the continuous comparison method. Thus, it was ensured that the codes used in the creation of the tables were consistent.

FINDINGS

This section presents the participants' evolations about the application processes of STEM activities, the reasons why they chose certain activities over others, the process of obtaining tools and materials for the activities, the challenges faced with the implementation of the processes and the prospective teachers' views on the applicability of STEM activities in general.

Findings concerning the reasons why a particular activity was chosen over another

The reasons for the participants' penchant for certain activities were determined by asking them the question "Why did you choose this activity? How did you develop it?" The opinions of the participants on this topic are given in Table 5.

Table 6. Reasons why the participants chose a particular STEM activity

Category	Code	Drawbridge	Electromagnet	Electroscope	The fastest car	Hydraulic lift	Hourglass	Catapult	Car made from fruit	Rowboat	Total
Applicability	Low-cost	1						1	1	1	5
	Easy application					1			1	1	4
	Accessibility of materials	1	1						1		3
	Simplicity	1			1						2
	Duration of activity	1	1								2
	Easy to understand				1						1
	Compliance with the objectives of STEM	1		1			1	1	1		6
Compliance with STEM disciplines	İnclusion of all STEM disciplines				1						2
	İmportance of the activity content				1		1				2
	İnclusion of the STEM disciplines of Math and Science						1	1			2
	Expert advice			1							1
	İnclusion of the STEM disciplines of Math and Engineering					1					1
	İnclusion of the STEM disciplines of Math, Engineering and Science	1									1
	Beneficial			1	1						2
Learning	Educational potential					1					1
	Provides permanent learning								1		1
	Offers ease of learning								1		1
	Provides effective learning								1		1
	Delivering new products		1								1
Product properties	Allows product variety				1						1
	Product aesthetics								1		1

As seen in Table 6, the most frequently mentioned codes in the category of applicability, cited among the reasons for the preference of certain STEM activities over others, were low-costs (5) and ease of application (4). İn the category of compliance with STEM disciplines, conformity with the objectives of STEM (6) and the inclusion of all STEM disciplines (2) were the most frequently mentioned codes, as reasons for choosing certain activities while usefulness (2) was the most frequently mentioned code in the category of learning. As for the category of product features, the determined codes were "it delivers new products" (1), "it allows for product variety" (1) and "product aesthetics" (1).

Findings concerning the procurement of tools and materials

Following a review of STEM activity plans and the responses to the question "How did you obtain the tools and materials" by the participants, it was established that the participants preferred more easily accessible tools and materials while planning what tools and materials to use for their STEM activities. The participants obtained the materials they utilized during the activities from their own houses, the stationery store or the supermarket. İt was also established that tools like tape (5), scissors (3), adhesives (3), balloons (3), plastic bottles (2), drinking straws (2), copper wire (2), retractable carpet knives (2), cardboard (2) and plastic glasses (2) were used in more than one STEM activity.

Findings concerning challenges with implementation of STEM activities

Questions like; "How would you assess the implementation process of your activity? Do you believe you have fulfilled the objectives? Did you experience any challenges during the implementation process? İf yes, at what stages?" were asked to determine if the participants experienced any challenges while implementing the activities and what sort of challenges then, if applicable. İn all groups that implemented the STEM activities, all participants stated that they fulfilled their objectives with the activities. The participants also stated that they did not encounter any difficulties that could not be overcome in the implementation process of the activities except for some minor difficulties. The categories and codes regarding the evaluations obtained from the participants' views on the difficulties they faced during the process are given in Table 7.

Table 7. Challenges faced by the participants when carrying out STEM activities

Category	Code	Drawbridge	Electromagnet	Electroscope	The fastest car	Hydraulic lift	Hourglass	Catapult	Car made from fruit	Rowboat	Total
Planning	Challenges with obtaining certain materials							1			
İntroduction	Ambiguity of instructions		1			1					2
	Not knowing the working principles of the end product					1					1
Process	Lack of manual skills		1								1
	Not being able to piece together a piece of wood							1			1
	Not being able to decide on the flexibility of the rubber (difficulties with adjustment).							1			1
Product	Product aesthetics		1								1
	Not accepting the emergence of an end product different from what was anticipated							1			1

As seen in Table 7, the participants' views on the difficulties they faced whilst implementing STEM activities were gathered under four categories, namely planning, introduction, process and product. While the most frequently repeated code was "not understanding the instructions" in the introduction category (2), no repeated codes were found in the process and product categories. Some codes concerning the difficulties with implementation of the activities were challenges with obtaining the materials (1) in the planning category; a lack of manual skills (1) in the process category, and product aesthetics (1) and "not accepting the emergence of an end product different from what was anticipated" (1) in the product category.

Findings concerning the applicability of STEM activities

Participants' views on the applicability of STEM education activities were determined through the questions "What are your overall views on the applicability of STEM education?, Would you consider integrating STEM activities into your teaching routine when you become a teacher? Why?" All participants responded that they found STEM activities applicable. While some participants mentioned the contributions of STEM activities to the learning process during the interviews, some expressed their misgivings concerning the efficient implementation of these activities. Opinions of the participants concerning the contributions of STEM activities to the learning process are illustrated in Table 8.

Table 8. Participant Opinions concerning the contributions of STEM activities to the learning process

Category	Code	Drawbridge	Electromagnet	Electroscope	The fastest car	Hydraulic lift	Hourglass	Catapult	Car made from fruit	Rowboat	Total
Teaching process	İnstructive		1		1	1	1	1		1	6
	Fun	1			1			1	1	1	5
	Attention-grabbing			1				1		1	3
	Puts concepts on a concrete basis			1				1		1	3
	Smooth teaching process	1									1
Learning	Supports permanent learning			1		1	1	1	1	1	6
	Supports learning				1	1	1	1	1		5
	Producer		1		1	1	1	1			5
	Facilitates learning						1			1	2
	Reinforces learning						1				1
Learning process	Creative application		1		1	1	1	1			5
	Helps with self-development		1		1		1				3
	Active participation							1		1	2
	Teamwork						1	1			2
	Problem solving		1					1			2
	İmproves manual skills				1						1
	Promotes scientific inquiry									1	1
	İnquisitive								1		1

As seen in Table8, the opinions of participants concerning the contributions of STEM activities were gathered under three categories, namely teaching, learning and education process. İt was determined that STEM activities were found to be instructive (6), fun (5), attention-grabbing (3) and concretizing (3) in the teaching process category; participants thought they provided permanent learning (6), supported learning (5) and encouraged students to be productive (5) in terms of the learning category, while their creative aspect (5) was found to be their most vaulted characteristic in the education process category.

Misgivings of participants about the applicability of STEM activities are illustrated in Table 9.

Table 9. Misgivings of participants about the applicability of STEM activities

Category	Code	Drawbridge	Electromagnet	Electroscope	The fastest car	Hydraulic lift	Hourglass	Catapult	Car made from fruit	Rowboat	Total
Preparation process	Difficulties with obtaining/accessing materials	1	1					1	1		4
	Requires planning and preparation			1				1			2
	High costs						1				1
	Time-consuming							1	1	1	3
	Lack of cooperation between teachers and students			1							2
Application Process	Failure to ensure the active participation of students					1	1				2
	Eagerness to do better overshadows learning							1			1
	Takes too much effort								1		1

As seen in Table 9, codes concerning the misgivings of participants about the applicability of STEM activities were collected under two categories, namely the preparation and implementation process. While procurement of materials (4) and the requirements for planning and preparation (2) were the most frequently mentioned codes in the preparation category; too much time-consuming (3) and failure to ensure active participation of students (2) were the most repeated codes in the implementation process category.

As opposed to the misgivings given in Table 8, all participants stated that they considered conducting STEM activities when they became teachers. They cited the factors that STEM activities support such as permanent learning (6), they are productive (5), fun (5), help with self-development (3), facilitate learning (2) and allow teamwork (2) to explain why they thought so.

DISCUSSION AND CONCLUSION

On the basis of the findings of the current study, which sought to examine the evaluations of prospective teachers about their experiences with planning and implementing STEM activities, it was established that the applicability of the activity in question, its compliance with STEM disciplines, its teaching potential and the product characteristics were decisive in determining what STEM activity to implement in the classroom. İt was also established that the participants gave importance to the low cost of activity materials and their easy accessibility. Obtaining materials is important for the implementation of STEM activities (Stohlmann et al., 2012). As many studies have shown that STEM activities cannot be performed due to reasons such as a lack of materials at schools or inadequate amount of materials at schools (Kutlu & Bakirci, 2018), access to materials only in schools or science centers during limited time periods, or the costliness of materials (Hardy, 2001; Nadelson & Seifert, 2017). However, STEM activities should not be associated with costly materials. All materials used for STEM activities carried out within the scope of this study were easily obtained from teachers' homes, supermarkets or stationery supplies. According to the results of the study, another important criterion in determining the STEM activities to be applied is the compatibility of the activity with STEM disciplines. However, the integration of the four disciplines that make up the STEM is not so easy when designing activities (Alan, 2017). According to Atkinson and Mayo (2010) and Brown, Brown, Reardon and Merill (2011), although four STEM disciplines are taught separately at schools, there are difficulties with providing STEM education with an integrated approach. İt is acceptable that teachers who are experts in their respective fields find it difficult to design activities that cover these four areas. This is due to the fact that it entails a process of developing integrated teaching materials. The steps to be taken in this process are the suitability for cooperation, the integration of different disciplines (Tekerek & Tekerek 2018). İn order to deliver effective STEM education in this context, teachers need to have an in-depth knowledge of these disciplines (Eckman, & et al., 2016), cooperate with others (Brown et al., 2011; Ugras & Genc, 2018) and teach students through a sound pedagogical approach (El-Deghaidy & Mansour, 2015).

İt was established that there were some minor difficulties in the implementation of STEM activities, but according to the participants' views, these difficulties were not insurmountable. Difficulties related to the implementation of STEM activities can be experienced in all three stages of the implementation process, namely introduction, process and outcome. Among some of these difficulties can be cited as ambiguity of instructions, lack of manual skills on the part of students, lacking product aesthetics and teachers' unwillingness to accept the emergence of an end product different from what was anticipated. Failure to understand the guidelines can be ascribed to the relative inexperience of participants with managing activities designed with an integrated approach outside routine teaching practices (Atkinson and Mayo, 2010; Brown, Brown, Reardon and Merill, 2011). A lack of manual skills on the part of students can be considered an obstacle to the effective use of the materials, thus causing difficulties with the STEM application process. Because while students who can use the materials effectively find STEM activities easy, students who have difficulties with using the materials experience more challenges (Akgunduz & Akpinar, 2018).

İt was established that all participants found STEM activities applicable. The participants thought that STEM activities contributed to the teaching process as they are instructive, fun, attention-grabbing and concretize learning; as well as to the learning process since they provides permanent learning and encourage students to be productive. They also thought these activities contribute to the education process as they promote creativity, encourage students to be more active and allow teamwork. The finding is consistent with the results of other studies in the literature. These studies showed that teachers, when properly introduced to the STEM approach and STEM activities, thought STEM activities were fun, effective and instructive (Altan, Yamak and Kirikkaya, 2016), and supported scientific process skills and problem-solving skills (Alan, 2017; Aygen, 2018). İt was also found that teachers thought that the STEM approach increased students' motivation and interest towards lessons (Cavas, Bulut, Halbrook &Rannikmae, 2013; Hacioglu, Yamak & Kavak, 2016; Yildirim & Selvi, 2017), that the integrative approach that brings together STEM disciplines was necessary and effective for success in math (Judson & Sawada, 2000), that they positively supported the development of students' reflective thinking skills (Gulhan & Sahin, 2016; Pekbay, 2017), that these activities would allow students to think more broadly, that they would improve their decision-making skills and increase the usage of labs (Kutlu & Bakirci, 2018). Studies conducted with the students found that students had positive perceptions about STEM activities. Gokbayrak and Karisan (2017) found that students found these activities useful in many aspects, while Pekbay (2017) found that students found STEM activities fun and that they collaborated with one another and actively learnt when doing STEM activities. Cho and Lee (2013) found that STEAM activities where STEM and art are combined support middle school students' creativity (creative problem solving and creative personality) and improve learning levels. On the other hand, Bozkurt Altan, Yamak and Bulus Kirikkaya (2016) found that the implementation of STEM activities during lessons increased the academic achievement of students, supported permanent learning and provided meaningful learning while Yildirim and Selvi (2017) argued that the same thing applied to the implementation of these activities together with the complete learning model. İn addition to the results from this study, there are also studies showing that with STEM applications, students gain valuable competencies in science and mathematics and can develop 21st century skills such as creativity, critical thinking, collaboration and communication (Moomaw & Davis, 2010; Hacioglu, Yamak & Kavak, 2016; Akgunduz & Akpinar, 2018). İn this context, it can be said that STEM exercises support students' development in many aspects and that teachers and prospective teachers with experience in these activities find them doable.

İt was also established that all participants were considering to carry out STEM activities in their professional lives. According to studies conducted by Haciomeroglu (2018), Ozbilen, (2018) and Cinar, Pirasa and Sadoglu (2016), prospective teachers with a first-hand experience of STEM activities consider integrating STEM activities into their teaching routines in the future. İt may also have contributed to the participants' positive feedback on these activities that they receiving an applied STEM training. Because teachers with an applied STEM training develop positive attitudes towards the implementation of the STEM approach in the educational process (Du, Liu, Johnson, Sondergeld, Bolshakova & Moore, 2019; Thibaut, Knipprath, Dehaene & Depaepe, 2018b). However, in his research on engineering-based science applications, Capobianco (2011) found that even though most of the prospective teachers taking part in the research found the process interesting, some of the prospective teachers had concerns about using such activities in their classrooms as they found the implementation or the preparation process too complicated.

İt was also found in this current study that the participants considered incorporating STEM activities into their teaching routine but that some had concerns about the prep stage and the implementation process. İn this context, it was established that the most remarkable concern regarding the prep stage was the supply of materials and the need for preliminary preparation for the activities; while among the most frequently voiced concerns concerning the implementation stage were the time-consuming nature of the activities, efficient implementation of the STEM activities by the students, lack of cooperation between students, lack of active participation on the part of students and lack of materials. Other studies with similar results regarding the concerns on the part of teachers about STEM activities defined costs, procurement of materials, the time-consuming nature of the activities (Delen & Uzun, 2018; Eroglu & Bektas, 2016; Hacioglu, Yamak & Kavak, 2016) and lack of teacher equipment (McDonald, 2016; Ozbilen, 2018) as the primary obstacles complicating the implementation process. İn her research on the obstacles compromising the successful implementation of STEM education, Eijawale (2013) stated that the lack of good training and professional support of STEM teachers conducting STEM activities constituted a major obstacle for precluding successful STEM practices.

Corlu (2014) and O'Brien, Karsnitz, Sandt, Bottemley and Parry (2014) also state that prospective teachers start their careers without reaching a professional competency in integrated teaching required for success with STEM activities. Similarly, Yildirim and Selvi (2016) found that prospective teachers studying at universities did not have sufficient knowledge and skills about STEM education and found it difficult to transfer STEM education to actual life scenarios. Moreover, Kutlu and Bakirci (2018) also found that teachers in the field did not have sufficient knowledge about the STEM education, while Brophy, Klein, Portsmore and Rogers (2008) argued that teachers needed professional support on the combination of STEM disciplines around a central topic through pre-service and in-service training programs. Lee, Hsu and Chang (2019), Guzey, Tank, Wang, Roehrig, and Moore (2014), Stolhmann, Moore and Roehrig (2012) found that teachers felt inadequate about themselves when conducting STEM activities in the classroom, particularly those that are engineering-based, while El-Deghaidy and Mansour (2015) found that teachers lacked the skills for integrating technology and the nature of science. İn this context, it can be argued that equipment is an important factor for efficient STEM applications and for fulfilling the purpose of the activities.

Suggestions

İn this study the STEM activities are limited to those which can be done using waste or concrete materials. . İn this context, materials such as electronics and robotics support can be given to the practitioners for implementing various STEM activities. Thus, the limitation of STEM activities to be carried out only with cheap and accessible materials can be overcome. İn addition to this, it is observed that there is difficulties to integrate more STEM disciplines in STEM activities. To overcome this handicap, teachers can be trained to integrate more STEM disciplines in STEM activities. This study was conducted with prospective teachers, similar research can be carried out with teachers and in classroom settings of secondary or high schools.

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