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STEM Education Program for Science Teachers: Perceptions and Competencies *

Esra BOZKURT ALTAN[1] , Serhat ERCAN[1]

[1] Assistant Prof. Dr., Sinop University, Faculty of Education, Sinop-TURKEY

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ABSTRACT

This study focused on the professional development activities carried out at Sinop University during the summer of 2015. The purpose of the study is to investigate the effects of the professional development program on the participating science teachers' perceptions and competencies as they relate to STEM education. 24 science teachers were participated the program which was organized to promote their acquisition of the competencies necessary for the development and implementation of original activities suitable for STEM education. The study was carried out through qualitative paradigm. One of the data sources used was to "Teachers' Perceptions on STEM Education Questionnaire". STEM education teaching plans which were developed by teachers during the program were the other data sources used by the study. Findings from the TPSEQ suggest that the professional development program positively affected teachers' views of STEM education. Additionally, after the professional development program, participating teachers made suggestions for the (engineering) design based science instruction for the adaption of STEM education. It can be suggested that in-service training programs should be developed for teachers to raise their awareness of the necessity of STEM education and to enhance their competencies in planning, implementation and evaluation of an instructional process suitable for this approach.

Keywords: STEM Education; Interdisciplinary Education; Science Education.

INTRODUCTION

We live in a century in which developments in the fields of science, technology, engineering and mathematics affect almost every part of our modern life (Brophy, Klein, Portsmore, & Rogers, 2008; NRC [National Research Council], 2012; NGGS [Next Generations Science Standards], 2013). The impact of technological innovation brought about by developments occurring in the fields of science and technology and economic growth is getting bigger and bigger. It is necessary to adapt to these developments, which are occurring at an overwhelming speed and which are exercising influences on countries (International Technology Education Association [ITEA], 2007). This encourages countries to train the engineers and scientists of the future (Miaoulis, 2009) and to improve the literacy of the society in these fields (Miaoulis, 2009; Roehrig, Wang, Moore & Park, 2012).

In recent years, at the root of the reform movements in the field of education was concerned with the restructuring of the educational programs and was directed at the integration of science, technology, engineering and mathematics disciplines (STEM) at K-12

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Corresponding author e-mail: esrabozkurt@sinop.edu.tr

level (Asghar, Ellington, Rice, Johnson & Prime, 2012; NAE, 2010; NAE and NRC, 2009; Williams, 2011;) demonstrating that the issue has been addressed by the policies developed by countries.

STEM education invests efforts to integrate the disciplines of science, technology, engineering and mathematics by establishing connections between real-life problems; that is, the problems are multi-disciplinary. On the basis of the implementation of these disciplines to real-life problems, borders between the disciplines should be abolished. Each STEM discipline brings a different competency and viewpoint but as in real life, for a successful team, teamwork is the key term (NAE & NRC, 2009; Wang, 2012). This approach points out integrated education programs capitalizing on the knowledge and skills of every discipline (Roberts, 2012). However, given the current elements of education programs, it is clear that adoption of such an approach requires the restructuring of many elements ranging from the training of STEM teachers, changing the structure of education programs from the revision of measurement-evaluation methods and the cost and time of making such big changes stand as an barrier in front of this reform (Bybee, 2010; NAE & NRC, 2009; NRC, 2012). Though America and many European countries have already started to make these changes required by STEM education, research suggests different approaches for the implementation of STEM education within the context of current circumstances (Bybee, 2010; Dugger, 2010; Sanders, 2009). These approaches suggest different combinations of the disciplines such as putting the main emphasis on science and mathematics and keeping technology and engineering secondary, embedding each discipline into another or incorporation of all the other STEM disciplines into one of them. The approach most suitable for meeting the expectations from STEM education is the one entailing the incorporation of the others into one of the STEM disciplines; for example, integration of mathematics, engineering and technology into the science program.

The professional development of teachers is important to STEM education. Teacher professional development programs will need to provide learning opportunities for teachers themselves in order to deepen their conceptual understanding, engage in scientific and engineering practices, and develop an appreciation of science as a way of knowing in a community of knowledge builders (NRC, 2012). Research has identified that professional development is important in STEM Education (Apedoe, Reynold, Ellefson ve Schunn 2008; Capobianco, 2011; Capobianco, 2013; Cuijck, Keulen, Jochems, 2009; Felix, 2010; Hsu, Purzer, Cardella 2011).

This study focused on the professional development program carried out at Sinop University during the summer of 2015. The purpose of the study is to investigate the effects of the professional development program on the participating science teachers’ perceptions and competencies as they relate to STEM education.

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METHODOLOGY

The current study aims to investigate the effects of the professional development program on the participating science teachers’ perceptions and competencies as they relate to STEM education. The study was carried out through qualitative paradigm

a) Study Group

The study group of the current research is 24 science teachers (14 females, 8 males) determined by means of purposive sampling selection method. Initially, a web site was designed to inform the participants about the professional development program. The program was publicized on social networking sites subscribed to by science teachers and the link to the website was shared. Teachers made online applications to the program. The applications were classified according to criteria including the length of time an individual has been teacher, the city in which the school is located and whether or not there had been previous participation in a similar program. Following these considerations selection was made among the teachers in such a way as to construct a heterogeneous sample in terms of the selection criteria. The science teachers constituting the study group are from seven different regions of the country and have a length of service ranging from 1 year to 15 years. None of the teachers have participated in a similar program before.

b) Context of the Study

A nine-day professional development program was organized to promote the science teachers' acquisition of the competencies necessary for the development and implementation of the original activities suitable for STEM education. The professional development program [STEM Education Approach: Strengthening of Science Classes through Interdisciplinary Ties] was supported by TÜBİTAK. The program was conducted at Sinop University between 21-29 August 2015. The date of the program was the last period of the teachers' summer holiday. The program consisted of theoretical and applied activities designed to promote the teachers' understanding of the nature of STEM and its' implementation of it in their science classes. While STEM Educations' Theory and Implementation, STEM Education and the Characteristics of Future Teachers, The Nature of Science and Engineering and The Applicability of STEM in Science Education were the theoretical activities of the program. Robotic applications and calculative thinking, the use of probes, science instruction through lego pieces, designing an environmentally friendly living space, designing a solar vehicle, fixing of a coordinate with GPS, generating water hardness and intensity maps, deterioration and storage conditions of water products and design-based science implementation were the applied activities in which the teachers actively participated. The activities were conducted by 15 specialized and experienced academicians from 7 different universities.

c) Data Collection and Analysis Process

The data of the current study were collected through "Teachers' Perceptions on STEM Education Questionnaire" developed by the researchers and STEM teaching plans developed by the participants.

Teachers' Perceptions on STEM Education Questionnaire (TPSEQ)

In this questionnaire, there are five questions asked to elicit what the participants know about STEM education, why they think that such an approach is needed, its importance for our country, how STEM education can be applied in classes and the extent to which they consider themselves competent in the implementation of STEM. The data collected with this questionnaire were qualitatively analyzed by using content analysis and comparative analysis techniques together. Each teacher numbered their forms (The form of the first teacher was numbared as Ö1). Initially the responses of each teacher given to the questions were revised in such a way as to allow comparative analysis. The responses of every teacher to the each question on the form were separately analyzed and coded. Two researchers individually constructed their lists of codes individually and similarities and differences between the lists were identified. The differences were revised and when necessary, the opinions of a third expert was sought. The final list of codes was constructed on the basis of words, whole sentences or paragraphs and after making comparisons between the codings, categories were formed on the basis of the predominant themess and thus the coding list was simplified and its final form was determined (Bogdan & Biklen, 2007; Gay, Mills & Airasian, 2006). One category obtained through the above-mentioned analysis process and a series of codes listed under this category is given in Table 1 below.

Table 1. *Sample category and codes*

Category	Code
STEM-oriented Skill Development	Interdisciplinary inquiry skill
	Interdisciplinary problem solving skill
	BSB
	Decision-making skill

How the codes constructed as a result of the analysis of the pre-service teachers' responses and presented in Table 1 were attained is exemplified below:

Sample Category: STEM-oriented Skill Development,

Sample Code: Creativity in STEM areas

Teacher Response: *"…When these areas are integrated, an individual can come up with original things while developing something because I think, when the individual can integrate mathematics, technology and engineering, he/she can improve his/her creativity and think more comprehensively…"*

STEM Teaching Plans

On the last day of the program the teachers were asked to develop STEM teaching plans in order that an in depth analysis could be carried out of any changes to their opinions regarding their competencies in developing, teaching and conducting STEM education processes in their classes. The teachers were divided into five groups and they were given 180 minutes to determine the objectives from the science course teaching program. The teachers were asked to develop their teaching plans in line with Design-based Science Education, one way of conducting STEM education in science classes. The teaching plan prepared by the 2nd group is presented in the Table 2.

Table 2. *Teaching Plan Prepared by 2nd Group*

Unit: Matter and Heat The aim of this unit is to ensure students comprehend heat conduction and insulation, heat insulation technology', contribution to family and the national economy, fuel types, and the environmental impact of the fuel used for heating purposes. **Suggested Time:** 8 one-hour lessons **Learning Objectives:** Classifies the matters according to heat conduction. Discusses the importance of heat insulation according to family and the national economy and the effectiveness of sources. States the criteria of heat insulation materials' electing. Improves the alternative heat insulations materials.
Design Challenge: Students will be expected to design a building for Istanbul city. The designs' success criteria are maximum energy efficiency, the lifetime of materials, and the total cost of design. *"Rubric will be prepared to evaluate the design."*
Mini Design Challenge: We are investigating the energy efficiency *"The aims of this activity is for students to understand, design and discuss the most effective heat insulation for buildings and why heat insulation is important"* **Mini Design Challenge:** Designing an Insulator *"In this activity, the aim is to design an effective insulation for a cup of cold soda using different materials such as cotton, aluminum foil, wool etc., gaining an understanding of how different materials can facilitate or slow heat transfer."* **Mini Research:** Heat insulation materials for building… *"There are plenty of cheap and common insulation materials available on the market today. Many of these have been around for quite some time. Each of these insulations have their own advantages and disadvantages. The choice of insulation material can be very important and in this activity students investigate the properties of heat insulation materials. They will consider differences including price, environmental impact, flammability, and other factors.*

The teaching plans prepared by the teachers were analyzed on the basis of the criteria developed by considering the design based science instruction and education plan development steps proposed by Wendell et al. (2010, p.6) and the features to be possessed by design problems defined by Crismond (2001). These criteria are as follows:

• *8-10 science (and engineering) objectives intended to be incurred in students need to be determined.*

• *A comprehensive engineering design task that will allow conducting scientific research related to learning objectives needs to be determined.*

• *The design tasks should include sub-tasks that will constitute the real life context.*

• *The design task should be able to be conducted with materials known and easy-to-use.*

• *The design task should allow more than one design solution.*

• *The design task should be supportive to cooperative work.*

• *The design task should be suitable to be conducted by repeatable steps so that design products can be improved and enhanced.*

• *Activities to prepare students for the design task should be determined (mini design/ mini research).*

The teaching plans were presented by the groups and three science education experts experienced in STEM education evaluated the presentation on the basis of the above-given criteria and then the teachers were given feedback. The evaluations were video-recorded. In order to establish the reliability, the same teaching plans were reevaluated five weeks later and the same results were obtained.

FINDINGS

Perceptions about STEM Education

TPSEQ was administered to the teachers before and after the program and comparisons were made on the themes and the categories and codes subsumed under these themes on the basis of the analysis of their responses. The data gathered in this way will be presented separately under the themes of "Reasons for the Necessity of STEM Education, Adaptation of STEM into Education System, Perceptions about the Barriers to Implementation of STEM Education and The Proficiency Perceptions of Teachers about STEM Instructional Process Planning, Implementation and Evaluation.

Perceptions about the Reasons for the Necessity of STEM Education

From the teachers' responses given to the first and fourth questions in TPSEQ, it was attempted to determine their perceptions about the reasons for the necessity of STEM Education. The findings obtained as a result of the analysis of the responses given to these questions are presented in Table 3.

As can be seen in Table 4, before the program, the teachers viewed developing positive attitudes towards STEM areas (f=12), enhancing creativity (f=11) and interdisciplinary inquiry (f=6) skills and improvement of academic achievement (n=7) as important reasons for the necessity of STEM education. After the program, it was found that none of the teachers consider academic achievement as an important reason for the necessity of STEM education. After the program, the teachers put greater emphasis on the necessity of STEM education for improving the creativity in STEM areas (f=18), interdisciplinary problem solving (f=9) and inquiry skills (f=7) and technology-utilization (f=6). Thirteen of the teachers mentioned developing positive attitudes towards STEM areas and five of the teachers mentioned lack of motivation as reasons for the STEM education after the program and the frequencies of these two reasons are very close to each other before and after the program. After the program, the teachers added two more reasons for the necessity of STEM education that are having a say in scientific developments (f=15) and increasing the level of development of a country (f=5) and they indicate that the teachers developed some ideas about the societal contribution of STEM. Another change observed in the perceptions of the teachers as a result of the program is that STEM education is necessary for people desiring a career in engineering (f=5).

Table 3. *Teachers' Perceptions about the Reasons for the Necessity of STEM*

Category	Codes	Pretest	Posttest
		f	f
Improvement of STEM Knowledge	Improvement of STEM academic achievement	7	-
Skill Development	Interdisciplinary inquiry skill	6	7
	Interdisciplinary problem solving skill	1	9
	Creativity in STEM areas	11	18
	Technology-utilization skill	1	6
	Scientific process skills	1	2
	Decision-making skill	-	1
Affective Behaviors Development in STEM areas	The need for a generation having positive attitudes in STEM areas	12	13
	Lack of motivation in STEM areas	3	5
Societal contribution of STEM	Having a say in scientific developments	-	15
	Increasing the level of development	-	5
Career Development in STEM Areas	Training scientists	1	-
	Training engineers	-	5

Some of the opinions expressed by the teachers in the pretest and posttest about the reasons for the need for STEM are as follows:

Ö2-Pretest: "Unfortunately, our country can't keep up with the technological developments in the world, let alone producing these technologies. Individuals who are far away from science literacy and scientific thinking are educated, there are still individuals experiencing difficulty in using technology; therefore, I think that STEM education should be put into practice in classes"

Ö3-Pretest: "In my opinion, given that children's interest in science is gradually decreasing, STEM education is of great importance for our country to create a generation interested in science"

Ö5-Pretest: "I think that STEM education is of a vital importance for our country because we have not been able make a great stride in the field of science for years. In this regard, one of the key points to be considered is that science education should be in integration with other disciplines as it is in the real world. That is, they should be provided with opportunities to make interdisciplinary comparisons…"

Ö11-Pretest: "Science, technology, engineering and mathematics are indispensable for thinking brains. In my opinion, our country needs students liking these disciplines. By means of STEM education, I think that a generation interested in these disciplines can be created."

Ö1-Posttest: "STEM intends to educate individuals who can produce, solve problems, conduct analysis and are literate in the related disciplines. We need STEM to have qualified engineers, scholars, teachers and society in general. In the long run, STEM will make important contributions to the development of our country."

Ö2-Posttest: "… In my opinion, the most important objective of it should be to eliminate negative attitudes in the fields of science and to endear these fields…"

Ö7-Posttest: "Within the context of STEM education, training focusing on the production of solutions to problems is given. Students learn science by encountering and finding *solutions to problems. In this way, skills required to think and inquire are developed in science-related disciplines."*

Ö15-Posttest: "I think that STEM education will yield important benefits for our country in the long-term. Teaching children how to question and design will positively affect both their personal lives and their achievements in academic fields. Thus, children will be confident enough to find solutions to their problems. Given that one of the important problems in our country is production, innovative production efforts could be invested as a result of such education."

Perceptions about the Adaptation of STEM to the Education System

The teachers' perceptions about how to adapt STEM education to the education system were elicited through the first and second questions in TPSEQ. The purpose of the third question is to determine the opinions about how it can be implemented in the current conditions (education programs in our country, teacher training, measurement and evaluation methods etc.).

Findings related to the teachers' perceptions about how to adapt STEM education to the education system are presented in Table 4.

Table 4. *Teachers' Perceptions about how to Adapt STEM Education to the Education Program*

Category	**Codes**	**Pretest**	**Posttest**
		f	**f**
Adaptation of the current conditions to STEM education	Development of STEM instructional program	5	-
	STEM teacher training	5	-
Adaptation of STEM education to the current conditions	Connection of mathematics to science courses	5	-
	Connection of technology to science courses	3	-
	Connection of engineering to science courses	5	-
	Out-of-school project works	-	2
	Cooperation between teachers	-	2
	Engineering-focused science courses	-	18

When Table 4 is examined, it is seen that before the program, the teachers suggested that a separate STEM instructional program should be developed (f=5) and STEM teacher training be conducted (f=5) but after the program they gave up this suggestions. Some of the teachers believe that STEM education should be implemented without making radical changes in the current conditions. These teachers stated that this adaptation could be achieved by incorporating mathematics (f=5), engineering (f=5) and technology (f=3) into science courses before the program. After the program on the other hand, none of the teachers mentioned such an integration and they mostly mentioned engineering-focused science courses (f=18). While few teachers pointed out that cooperation should be made between teachers for the integration of STEM education under the current conditions (f=2) and such an integration could be achieved by means of out-of-school projects (f=2).

Findings related to the teachers' perceptions about STEM implementation under the current conditions (instructional program, teacher training, measurement-evaluation etc.) are presented in Table 5.

Table 5. *Teachers' Perceptions about how STEM Education can be adopted to the Education System in the Existing Conditions*

Category	Codes	Pretest	Posttest
		f	f
Suggestions for Teachers	Cooperation between the concerned teachers	7	21
	In-service training for teachers	12	8
	Teachers' becoming open to development	6	4
Suggestions towards Course Process	Interdisciplinary relationships while teaching the subjects	1	1
	Daily life context	1	-
	Integration of technology	1	1
	Product-focused	1	-
	Design-based science	-	14
Suggestions for Out-of-class Activities	STEM workshops	1	3
	Science festivals	1	-
Other Suggestions	Student-centered	3	1
	Activity pool suitable for STEM	7	5

As can be seen in Table 5, it is seen that prior to the program, the teachers mostly thought that in-service teacher trainings should be given (f=12), cooperation between teachers should be increased (f=7) and teachers should be open to personal development (f=6) for the implementation of STEM education under the existing conditions. Another important element pointed out by the teachers for the STEM education is the construction of the activity pool suitable for STEM (f=7) before the program. After the program, more emphasis was put on the cooperation between teachers (f=21). Prior to the program, the teachers were able to make very few suggestions related to what should be done during the instructional process and made more general suggestions in relation to teacher training. However, following the activities at the program, most of the teachers made suggestions regarding instructional process and stated that design-based science education could be adopted (f=14) and integration of technology, engineering and mathematics into science courses can be achieved. This may indicate that the program contributed to the teachers' competencies in relation to in-class implementations.

The findings presented in Table 4 show that before the program, the teachers thought that the adaptation of STEM into the education system can be achieved by making changes in the education program and teacher training system or within the context of the existing conditions. Following the program, almost all of the teachers made suggestions for the adaptation within the context of the existing conditions and this may indicate that as a result of this nine-day training program, the teachers started to think that the adaptation can be achieved without making radical changes when teachers take some responsibilities.

Some of the opinions stated by the teachers in the pretest and posttest about how to adapt STEM education to the education system under the existing conditions in general are as follows:

Ö8-Pretest: "Course plans complying with STEM education should be developed … If this is to be done under the existing conditions, we should be trained"

Ö9- Pretest: "If we are expected to do this under the existing conditions, then the starting point for STEM education should be science education. As it involves mathematical skills, technology and engineering, it can be easily implemented in science courses. First, plans should be developed for courses, setup needs to be designed well. …Of course, first we need to understand the logic of STEM well; thus, we should be trained. Teachers may cooperate for the effective implementation of STEM."

Ö10- Pretest: "I do not think that STEM disciplines are completely disconnected. Science makes use of mathematics to a great extent. But, I do not know what will happen when the *subjects taught in courses are not parallel to each other… In my opinion, STEM training programs should be organized and we need to participate in them.”*

Ö12- Pretest: “We can connect it with technology, by using the tablets given to students, by showing that tablets are not only for playing games or taking photographs but they can also be used to study and research. We can download books into tablets…”

Ö1- Posttest: “For us to integrate STEM education into our schools, first teacher training programs should be revised on the basis of STEM education and teachers who can implement this approach should be trained. In addition to this, by means of in-service training programs, teachers can be trained for the implementation of this approach. Besides training teachers, education programs can be revised to adjust them to this approach. Science teachers should create connections with other disciplines and can develop their own course programs in line with this approach.

Ö7- Posttest: “We can adapt it first by constructing the required infrastructure in our schools. Then, cooperation among teachers should be established. Training of science teachers is of great importance for this integration …”

Ö11- Posttest: "…Teachers should be educated about STEM by means of in-service training programs or such projects. At the same time, teachers should be in contact with each other; we can share our course plans.”

Ö17- Posttest: “We conduct science courses by assigning design tasks to students; we can develop teaching plans for this purpose. But first we need to get in-service training.”

Findings related to the Teachers’ Perceptions about the Barriers to Implementation of STEM Education

The teachers’ perceptions about the barriers to implementation of STEM Education were attempted to be elicited by analyzing the responses given to the first question in TPSEQ and are presented in Table 6.

Table 6. *Teachers’ Perceptions about Barriers to Implementation of STEM Education*

Category	**Code**	**Pretest**	**Posttest**
		f	**f**
Teachers	The profile of a teacher not open to new ideas	3	-
Students	Student readiness	-	1
Teaching program	The content of the teaching program is not suitable	6	-
Teacher education	Improper teacher qualifications	10	7
Measurement and evaluation approach	Centralized exams	2	3
Others	Technical facilities	2	4
	Cost	6	-
	Time	2	4
	Difficulty in integrating the knowledge and skills of different disciplines	2	3
	Prejudiced parents	1	-

As can be seen in Table 6, both before (f=10) and after the program (f=7), the teachers viewed the biggest barrier to implementation of STEM Education as improper teacher qualifications. Other factors believed to be barriers to implementation of STEM Education were the structure of the teaching program (f=6) and costs (f=6) before the program but the teachers gave up seeing them as be barriers after the program. This might be because of the experiences of the teachers during the program; as a result of these experiences they started to believe that adaptation of STEM could be achieved under the existing conditions and its cost would not be too high.

The Proficiency Perceptions of Teachers about STEM Instructional Process Planning, Implementation and Evaluation

The proficiency perceptions of teachers about STEM instructional process planning, implementation and evaluation were attempted to be elicited through the analysis of the responses given to the fifth question of "TPSEQ" and are presented in Table 7.

Table 7. *The Proficiency Perceptions of Teachers about STEM Instructional Process Planning, Implementation and Evaluation*

Field of competency		**Yes**	**Partially**	**No**
Planning	Pretest	-	6	18
	Posttest	6	8	-
Implementation	Pretest	-	8	16
	Posttest	20	4	-
Measurement-evaluation	Pretest	-	6	18
	Posttest	18	6	-

When Table 7 is examined, it is seen that when compared to how they perceptions' before the program, the teachers started to feel more confident about planning, implementation and measurement-evaluation dimensions following the program. This might have resulted from the active participation of the teachers in many activities related to STEM education during the program.

Some of the opinions stated by the proficiency perceptions of teachers about STEM instructional process planning, implementation and evaluation in the pretest and posttest about as follows:

Ö4-Pretest: "The most important challenge is the shortage of teachers competent enough in these fields; moreover, the content of education programs is not suitable."

Ö6-Pretest: "The challenges may stem from the teacher's not being open to different approaches. Or even if it is adopted by the teacher, lack of equipments or shortcomings in infrastructure may lead to some other problems. Another problem can be incompliance between educational programs and STEM education."

Ö10-Pretest: "The existing teachers have been educated through traditional methods and their being closed to new things. Time can be another problem. Cost is an important barrier considering the present state of education in the country. Moreover, our education program is not suitable for the integration of STEM."

Ö2-Posttest: "Time-induced problems, technical possibilities, readiness level of students, qualifications of teachers"

Ö5-Posttest: "Some challenges can be encountered in the adaptation to the science course due to qualifications of the teacher. Moreover, physical conditions are important."

Ö8-Posttest: "The barriers to implementations of STEM education might be lack of information about this educational process on the part of teachers and parents' prejudices in relation to teacher-student-parent synchronization."

Ö21-Posttest: "…The biggest problem is the centrally-administered exams…"

Findings related to Teaching Plans

The findings obtained by analyzing the teaching plans prepared by the teachers according to criteria formed on the basis of Wendell et al. (2010, s.6) and Crismond (2001) are presented in Table 8.

Table 8. *Findings Related to the Teaching Plans Prepared by the Teachers*

		1st group	2nd group	3rd group	4th group	5th group
8-10 science (and engineering) objectives intended to be incurred in students need to be determined.	Yes	√			√	
	Partially		√	√		√
	No					
A comprehensive engineering design task that will allow conducting scientific research related to learning objectives needs to be determined.	Yes	√	√	√	√	√
	Partially					
	No					
The design tasks should include sub-tasks that will constitute the real life context.	Yes	√	√	√	√	√
	Partially					
	No					
The design task should be able to be conducted with materials known and easy-to-use.	Yes	√	√	√	√	√
	Partially					
	No					
The design task should allow more than one design solution.	Yes	√	√	√	√	√
	Partially					
	No					
The design task should be supportive to cooperative work.	Yes	√	√	√	√	√
	Partially					
	No					
The design task should be suitable to be conducted by repeatable steps so that design products can be improved and enhanced.	Yes	√	√	√	√	√
	Partially					
	No					
Activities to prepare students for the design task should be determined (mini design/ mini research).	Yes	√	√	√	√	√
	Partially					
	No					

When Table 8 is examined, it is seen that the design-based science instruction plans prepared by the teachers as a way of achieving the integration of STEM into science courses are quite adequate in terms of the set criteria. While the teaching plans of the two of the groups (1st and 4th groups) meet all the criteria, the teaching plans developed by the others (2nd, 3rd, and 5th groups) are accepted to be partially adequate as they include science objectives fewer than 8. This finding shows that the teachers feel confident to a great extent about planning an instructional process suitable for STEM education.

RESULTS, DISCUSSION and SUGGESTIONS

While the teachers regarded STEM education as necessary to enhance academic achievement in these disciplines prior to the program, they did not consider it so after the program. The teachers believe that STEM education is needed to improve creativity, problem solving, inquiry and technology-utilization skills in and developing positive attitudes towards these disciplines. This was the case both before and after the program but more strongly after the program. Teachers had conducted activities in which they actively participated in relation to STEM education and they more strongly believed in the necessity of STEM education for the development of some skills. This finding concurs with the findings reported in the literature. As stated by Morrison (2006), through STEM education, students are enabled to improve their self-confidence, problem solving, technology-utilization skills and discovery skills, to be more innovative and technology literate, to think critically and reasonably. Marulcu & Sungur (2012) indicated which skills of the pre-service science teachers could be developed via the science course designed through an interdisciplinary integration built on engineering design approach and found that it could improve their three-dimensional thinking, creativity and reflectivity, scientific thinking, problem solving, versatile thinking, imagination and drawing. As a result of the program the teachers started to believe that STEM education has some societal contributions to make including having a voice in scientific development and improving developmental levels. Due to the impact of the rapidly advancing technological innovations of countries it was considered necessary in order to raise the awareness of science and careers (ITEA, 2007). Moreover, in the literature, research argues that awareness of science and career can be enhanced through the integration of STEM disciplines (Apedoe, et. al., 2008; Bozkurt, 2014). In this respect, increasing awareness of the teachers in terms of the necessity of STEM education as a result of the program is of great importance given that teachers play an important role in the education system.

Before the program, the teachers thought that the adaptation of STEM into the education system can be achieved by making changes in the education program and teacher training system or within the context of the existing conditions. Following the program, almost all of the teachers made suggestions for the adaptation within the context of the existing conditions. In reality, the current structure of schools and education programs is not suitable for a separate STEM course in terms of its objectives, content, instructional activities and evaluation methods (Bybee, 2010; NAE & NRC, 2009; NRC, 2012). The teachers' expressing opinions about changing and revising all of these elements for STEM education indicate that it will be difficult to carry out in the short-term due to time and money concerns and nearly half of the teachers before the program were of this opinion. Following the program, almost all of the teachers stated that adaptation should be conducted within the existing conditions and this indicates their belief that teachers should take responsibility in this respect. This finding is supported by the opinions expressed by the teachers about the barriers to implementation of STEM education emphasizing the importance of teacher qualifications. Both before and after the program, the teachers emphasized the importance of developing teacher qualifications and cooperation between teachers. It is apparent that the teachers are cognizant of their responsibilities.

After the program, the teachers made suggestions for the design-based science instruction (Wendell, et. al., 2010) for the adaption of STEM education within the current conditions. In fact, as engineering design process that can be defined as the production process of technologies requires the use of basic engineering knowledge and skills and the principles of science and mathematics, it naturally ensures the integration of STEM disciplines (Cantrell, Pekcan, Itanı & Velasquez-Bryant, 2006; NAE & NRC, 2009;). Although the teachers were provided with opportunities to participate in different sample activities for STEM integration throughout the program, they suggested design based science education for the instructional process. Arafah (2011) conducted a study to investigate the changes taking place in the participating teachers' perceptions of engineering as a result of a three-day seminar program given about engineering design process to science and mathematics teachers and reported that the teachers' interest in the integration of engineering, technology, science and mathematics was increased at the end of this three-day program.

After the program the teachers also indicated that they felt competent about the planning, implementing, evaluation and evaluation of an instructional process in which the adaptation of STEM education is achieved because they were able to prepare teaching plans integrating STEM disciplines. Yasar Baker, Robinson-Kurpius & Roberts (2006) revealed that the teachers did not feel competent or felt inadequate while conducting instruction on design, engineering and technology. In a similar manner, in the current study, it was found that before the program, the teachers felt they were inadequate in achieving the integration of these disciplines. Sungur Gul & Marulcu (2014) found that after participating in activities about engineering design and the uses of legos for three days, the science teachers acquired basic information of engineering and were able to give some examples for engineering approach in science education; however, they could not internalize the process enough to use engineering design process to teach science concepts. Similarly, Arafah (2011) reported that though the interest of teachers in the integration of engineering, science, technology and mathematics was increased, they still felt inadequate. Unlike the studies of Arafah (2011) and Sungur Gül & Marulcu (2014) within the current study, a 9-day intensive program allowing teachers to actively participate in the activities was implemented and this long and intensive program may have led to teachers feeling more competent.

It can be recommended that in-service training programs should be developed for teachers to raise their awareness of the necessity of STEM education and to enhance their competencies in planning, implementation and evaluation of an instructional process suitable for this approach.

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