

The integration of STEM into science classes

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Abstract

The aims of this study are to reveal how science teachers integrate science, technology, engineering and mathematics (STEM) in their lessons and their opinions regarding the advantages and disadvantages they have identified while integrating STEM in their lessons, as well as what kind of difficulties they encounter in the implementation process. For this purpose, a semi-structured interview form was developed and qualitative research method was used. STEM is based on a holistic and interdisciplinary approach to the four disciplines rather than the independent teaching of these four disciplines. The study group comprises 12 science teachers in the province of Mugla in the 2017–2018 academic year. Research findings show that science teachers generally have a positive attitude towards using STEM-based activities but are not able to implement STEM-based activities in an appropriate, complete and accurate way because of difficulties in terms of ‘physical conditions’ and ‘time management’. Teachers stated that STEM education encourages students to do research.

Keywords: Science, science teacher, STEM education.

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1. Introduction

Science, technology, engineering and mathematics (STEM) was formed by combining the initials of the words (Sanders, 2009). Throughout our lives STEM has an important place in every aspect of life. It is imperative that future generations are equipped with knowledge and skills in the fields of STEM. For this reason, it is necessary to use approaches that will allow future generations to participate in these fields. One of these educational approaches is the STEM approach, which has been used in recent years (Turner, 2013).

STEM education encompasses integrated teaching practices that will comply with the work of professionals in real life in disciplines of STEM (NRC, 2012).

Using STEM disciplines together helps explain many situations in everyday life and solves problems. STEM education is crucial to developing today's indispensable skills: problem solving, self-improvement and systematic thinking skills (Bybee, 2010; Roberts, 2012). Today's education systems should aim to provide students with skills such as problem solving, creativity, research-questioning, critical thinking, entrepreneurship and communication, and the STEM education facilitates the learning and use of these skills. STEM education has positively affected students' ability to solve problems, be innovative, think critically, be technology literate and discover (Choi & Hong, 2013; Morrison, 2006).

STEM education provides students with one of the best opportunities to make sense of the world holistically, rather than in bits and pieces (Morrison, 2006). Real-world problems are seldom solved using knowledge from a single subject area. The school experiences of students should embody this reality, which in part has led to the increased focus on integrated STEM education (Green, 2014).

Well-designed STEM experiences can provide learning experiences that enable the engagement of a more diverse range of students (English, 2017). Education researchers indicate that teachers struggle to make connections across the STEM disciplines. Therefore, students are often disengaged in science and math when they learn in an isolated and disjointed manner missing connections to crosscutting concepts and real-world applications (Kelley & Knowles, 2016). STEM integration through the implementation of engineering design activities can also enable students to develop valuable twenty-first century skills including effective communication, technological savvy, innovation and synthesis of information (Green, 2014).

The STEM approach consists of four areas: science, technology, engineering and mathematics. Today, children encounter technology at a very early age. For this reason, it is very important to teach advantages and disadvantages of technology in a planned and controlled way. Engineering education is essential for students' in-depth learning and developing scientific process skills. Educating children in engineering at an early age makes a great contribution to their lives (Hester & Cunningham, 2007). Children are born as engineers, designing objects by splitting and combining provided materials. In this process, problem-solving and creativity skills are developed (Cunningham, 2009). In STEM education, it is stated that the problems encountered by students in real life are not related to a single discipline. Therefore, integrated teaching of STEM disciplines in STEM education is suited to real life situations (Asghar, Ellington, Rice, Johnson & Prime, 2012).

STEM education aims to educate qualified individuals in science, mathematics and engineering fields. STEM education in this context (Barnett, 2005; Fllis & Fouts, 2001; Thomas, 2014);

- Allows interdisciplinary work
- Improves children's critical thinking and advanced thinking skills
- Provides the training to become well-equipped individuals who are needed for the business world
- It allows information to connect with everyday life

- Provides industry–school cooperation
- Improves children’s knowledge and skills in engineering design process
- Contributes to countries’ economic and technological development.

STEM education allows students to learn in depth. In this context, it contributes to the academic success of the students (Yildirim & Selvi, 2017). Students’ scientific process skills contribute to problem-solving skills and development (Robinson, Dailey, Hughes & Cotabish, 2014). STEM education will equip individuals with the knowledge and skills necessary to be successful contributors to and benefactors of a twenty-first century economy (Schiavelli, 2008). To develop STEM skills, children should have some skills and experience (Gropen, ClarkChiarelli, Hoisington & Ehrlich, 2011). These skills are as follows: organising information, setting various strategies, focusing on learning, evaluating and planning.

Reported by Sahin, Ozgenol, Akbulut, Hascandan and Guley (2014), STEM practices improve children’s sense of courage before school. In addition, STEM activities ensure the permanence of the learned information. The STEM activities, together with the use of materials, have resulted in positive results in the way that students gain the habit of acting together and group fitting. Akaygun and Aslan-Tutak (2016) were shown that teachers did not have enough knowledge of engineering at the time of their work.

In this regard, the purpose of this study is to reveal science teachers’ opinion and their understanding of STEM education. Regarding this purpose, answers will be sought for the following questions:

1. How do science teachers integrate STEM education in their lessons?
2. What are the advantages and disadvantages of using STEM education reported by science teachers?
3. What difficulties are encountered in the process of implementing STEM education in science classes?

2. Method

A qualitative research method, phenomenology of which described as the existing situation was used in this study. Phenomenology is known as an educational qualitative research design (Marshall & Rossman, 2010). In phenomenological design studies, the purpose is usually to reveal individual perceptions related to a phenomenon and their interpretations (Yildirim & Simsek, 2016). Qualitative research is also used to uncover trends in thought and opinions, and dive deeper into the problem. Researchers who conduct phenomenological studies search for the ‘essential structure’ of a single phenomenon by interviewing, in depth, a number of individuals who have experienced the phenomenon (Fraenkel, Wallen & Hyun, 2012).

2.1. Data collection

In the preparation of the STEM education semi-structured interview form, the studies and resource books in the literature were examined (Honey, Pearson & Schweingruber, 2014; Hsu, Purzer & Cardella, 2011; Settles, Cortina, Stewart & Malley, 2007; Wyss, Heulskamp & Siebert, 2012).

The semi-structured interview form developed by the researchers was used as a data collection tool in the research. A semi-structured interview is a qualitative method of inquiry that combines a pre-determined set of open questions with the opportunity for the interviewer to explore particular themes or responses further. In the preparation of the interview form, expert opinions were received from eight experts, four of whom from the area of science education while the remaining four were from the area of measurement and assessment. A pilot study was conducted with two science teachers to evaluate understandability and relevance of the questions. At the end of this process, the forms were re-examined and re-arranged and made ready for implementation. The necessary corrections made on the interview form were examined. The questions were restructured and the number of questions was

reduced according to lecturer’s suggestions. Three questions regarding STEM Education were included in the semi-structured interview form, which was finalised with expert opinion. The data obtained from interviews were coded by researchers and another science educator and inter-coder reliability percentage was calculated as 92.44%. Over 70% of the reliability calculations are considered reliable for research (Miles & Huberman, 1994).

After the interviews are coded by the researcher, the interviews were evaluated separately by another researcher and the necessary arrangements were made by discussing the issues of ‘agreement’ and ‘disagreement’. The teacher interview records were then coded by another educator and the compliance coefficient was calculated. For this purpose, the reliability formula of Miles and Huberman (1994) was used.

Agreement percentage ‘Reliability = $P = N_a \text{ (Agreement)} / N_a \text{ (Agreement)} + N_d \text{ (Disagreement)} \times 100$ ’ (Miles & Huberman, 1994).

The data were analysed using descriptive analysis. The main purpose of descriptive analysis was to present the findings to the reader in an organised and interpreted way. The data obtained for this purpose is first described systematically and explicitly. The data obtained during the descriptive analysis is summarised and interpreted according to the previously determined theme. Later, the descriptions were explained, interpreted and concluded (Yildirim & Simsek, 2016). The privacy of personal information of the interviewed teachers is regarded by coding them as T1, T2, T3 ... T12. T1 points to first teacher while T6 represents the sixth teacher and T12 stands for the 12th teacher.

As a result of this calculation, the agreement coefficient is found as 92.44. According to Yildirim and Simsek (2016), it is assumed that the percentage of confidence is reached when the percentage of compliance in the reliability calculation is at least 70%. The percentage of incompatibilities between coders for this study is therefore acceptable. While qualitative analysis is conducted, direct quotations are made from participating teachers to support comments.

2.2. Working Group

In the province of Mugla, 12 science teachers who are working in the academic year of 2017–2018 were interviewed. Each interview was lasted for about 15 minutes. The information obtained from the teachers is recorded with a voice recorder during the interviews with permission and on the condition that all statements remain confidential. In the study group, 12 teachers are selected and used for purposeful sampling methods. The purposeful sampling method is useful in explaining facts and events in many cases (Yildirim & Simsek, 2016).

Table 1. Demographic characteristics of working groups

	Frequency	%
Sex		
Female	9	75.0
Male	3	25.0
Age		
21–25	–	–
26–30	1	8.3
31–35	2	16.7
36–40	3	25.0
41–45	3	25.0
46+	3	25.0
Seniority		
1–5	1	8.3

6–10	2	16.7
11–15	2	16.7
16–20	3	25.0
21–25	3	25.0
26+	1	8.3
Graduated University		
Faculty of Education	9	75.0
Faculty of Sciences	3	25.0

3. Results and discussion

Findings on Teachers’ responses to the question ‘How do you use STEM education in science course?’

Table 2. ‘How do you use STEM education in science course?’ question findings

Codes	Teachers	Frequencies
I use it in classroom activities	T1, T3, T6, T7, T11, T10, T12	7
I make modelling	T6, T11, T10, T12	4
I do not know	T2, T8	2
Assignment as homework	T1	1

Table 2 shows the importance of STEM education in the science course. According to research findings, almost half of the teachers interviewed used STEM education in classroom. Some teachers do not know what a STEM education is all about. Some science teachers said that they used STEM education in classroom activities during the learning–teaching process while only four science teachers out of 12 used STEM-based activities for modelling students. In the context of using STEM education in the teaching–learning process, the views of the T8 and T10 coded teachers are as follows:

T8: ‘I have not heard it before. That’s why I cannot comment much. Actually I need to know. But to tell you the truth, I do not know anything about STEM. Actually, I think it would be useful to use it in the classroom’.

T10: ‘I try to use it as much as I can, especially for modelling. The students participate actively in this way’.

Table 3. ‘The advantages and disadvantages of using STEM education in the science class’ question findings

Codes: Advantages	Teachers	Frequencies
Direction to search	T3, T5, T6, T7, T11, T12	6
Permanence	T1, T4, T9	3
Individual learning	T7, T10	2
Professional development guidance	T7	1
Codes: Disadvantages		
Time management	T1, T2, T5, T6, T12	5
No idea	T2, T8	2
Teacher exhaustion	T4, T7	2
Sustainability is not easy	T1	1
Teacher–Student communication disruption	T9	1

Table 3 shows the science teachers’ opinions on the advantages and disadvantages of STEM education in the learning–teaching process. The teachers mentioned that STEM education encourages students to explore their strengths. In addition, according to science teachers, STEM education offers students the opportunity to provide persistent learning. Some teachers have stated that STEM

education allow students to do very well on an individual basis. The views of the T7 teacher on the advantages of STEM education are as follows:

T7: ‘STEM education is driving students to do research and to think. That is, the student is trying to put things on his own and it helps them to do the research themselves, and at the same time to conceptualise it individually well’.

The views of the T5-coded teacher on the disadvantages of STEM education are as follows:

T5: ‘The teacher already has a lot of duties. There is a lot to do, especially about classroom management. When doing STEM education, it is time-consuming. We need to find a solution to this’.

As far as the disadvantages of STEM education, science teachers indicate the difficulty of time management for them. During the use of these activities, the lesson plan is deteriorating and it becomes harder to teach the topics that come in order. Some teachers have stated that the use of STEM education helps in the learning–teaching process. The views of the T6-coded teacher on the disadvantages of using STEM education are as follows:

T6: ‘STEM education is fairly new to us and we have not received any training in this regard. So if you do not intervene during the activity, you have to intervene at the end of the lesson’.

Table 4. Findings on the difficulties when using STEM education in science course

Codes	Teachers	Frequencies
Classes are crowded	T1, T4, T5, T10, T12	5
Content is too much	T1, T6	2
Students are having difficulties	T7, T9, T10, T12	4
Physical conditions	T3, T5, T12	3
Teacher’s lack of knowledge	T3, T9, T11	3
No knowledge	T2, T8	1

Based on the Table 4, almost half of the teachers interviewed said the fact that the classes are very crowded and therefore have difficulty in this regard. Again, in this direction, 4 out of 12 teachers stated that students were having difficulties in STEM education, and therefore the course was difficult to manage. Three of the teachers have mentioned about the ignorance of teachers in the use of STEM education and pointed to the lack of in-service training.

The three teachers stated that during the use of these activities, the physical conditions of the classroom, the school and the laboratory were not suitable and that it was a difficult situation to use STEM education under these conditions. In the context of the difficulties in using STEM education, the views of the teacher T12 are as follows:

T12: ‘When using STEM education, the main problem is that classes are very crowded, so class size must be no more than 15–20, so I can use these activities literally. In addition, the situation of the school is not suitable, and the physical environment is inadequate’.

The views of the teacher T9 indicates that students are having difficulties in STEM education as follows:

T9: ‘We do not have any training on STEM education. We have a knowledge base that consists entirely of our own efforts, which is not enough to use these events literally. Students may find it difficult to use these activities. For example, if you give a task to students, either their families do it for them or get it ready from Internet and bring it to us’.

4. Conclusion

At the beginning of the course, the most important features that should be gained by the students include production, creative thinking, problem solving, easy access to information, collaboration and critical thinking. STEM approach can provide students with an interdisciplinary point of view to gain creativity, critical thinking, high-level thinking skills and problem solving skills. In the twenty-first century, the need for scientifically thinking, interdisciplinary and creative thinking has increased (Akaygun & Aslan-Tutak, 2016). If the findings obtained within the scope of this research are generally evaluated and interpreted; science teachers seem to have a generally positive attitude towards using STEM education, but are not able to integrate STEM education at the implementation stage in an appropriate, complete and accurate way. However, teachers in the study group also consider advantages and disadvantages in the context of STEM education, which in general also suggests that teachers are more likely to overcome the disadvantages of STEM education. This can be interpreted as a positive view of science teachers' towards using STEM education in the learning-teaching process. When the relevant field is examined in the literature, it has been found out that teachers have positive views on the use of these activities in previous studies in the context of STEM education (Eroglu & Bektas, 2016; Siew, Amir & Chong, 2015).

When science teachers' findings include STEM education, it is seen that teachers use STEM education more in class activities and have students make models. Some teachers did not know what the STEM education was, and how it was applied. This situation is very worrying in terms of the future of science education. It is known that STEM education is highly influential on the individual's ability to have a more innovative brain structure that is open to inquiry and curiosity (Siew et al., 2015). In this case, in-service training of science teachers must be immediately reviewed and necessary precautions must be taken.

When science teachers' views on STEM education are used in the context of learning-teaching process, it is seen that these activities lead students to do research. Again, science teachers have also revealed that the use of STEM education in this regard has provided more permanent learning. When examining previous work on the benefits of using STEM education, (Cavas, Bulut, Holbrook & Rannikmae, 2013; Strong, 2013; Yamak, Bulut & Dundar, 2014) students have better understanding of scientific processes with these activities; it is also seen that it affects the students positively in affective and psychomotor area. When the findings obtained in the context of the disadvantages of STEM education in the learning-teaching process are examined, teachers are often referred to the concept of 'time management'. As a result, teachers' training does not seem to be effective in designing a STEM-based learning-teaching environment. Looking at the related field, Eroglu & Bektas (2016) are pointed out that one of the most important problems created by the use of STEM education is the time management.

If the problems faced by science teachers using STEM education are addressed, it can be said that the teachers of science are mostly in the crowded classes. Again, the teachers stated that when they use these activities, they also face difficulties in terms of physical conditions, students sometimes have difficulties and they face a number of problems arised by the ignorance of teachers. When the literature was examined, Siew et al. (2015) also found that the teachers had problems in terms of time management and course management when using these activities. In addition, Eroglu & Bektas (2016) reached the conclusion that the participant in the study they performed had suffered from time insufficiency and overemphasis.

5. Recommendations

In the science class, the following suggestions can be made as a result of the study conducted to make the related lesson more qualified in the context of the use of STEM education, and to make STEM education more comprehensive and more intuitive:

- In-service training of science teachers on the STEM education.
- Science teachers should investigate and educate themselves in the direction of new developments.
- For STEM education to be more widely used, physical conditions of the classroom and laboratory environment must be improved in schools.
- Time-consuming use of STEM education in the learning–teaching process may be inadequate. This can be done by leaving a separate classroom time, or an extracurricular study time for STEM education.
- In the context of disseminating the use of STEM education, these activities may need to be included in textbooks and be re-audited.

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