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Abstract

This study was a case study in which the results based on a specific case were analyzed and holistically described (Yıldırım & Şimşek, 2008). 15 middle school mathematics teachers took part in the present study. The participants were voluntary, and they were selected randomly. As data collection instrument, the researchers developed a semi-structured interview form including 5 open-ended questions. The gathered data were analyzed and reported through content analysis method. The results of the study showed that there was a consensus among teachers about interdisciplinary approach and integrating technology in mathematics instruction. Besides, it was revealed that the teachers were not knowledgeable about and trained on how to use technology and how to integrate science in mathematics instruction. The teachers agreed that regarding the integration of science and technology, mathematics curriculum was suitable and sufficient for the time required and for the topics involved. Based on the results of the study, it can be suggested that teachers be trained through pre-service and in-service integration programmes for the integration of science and technology in mathematics instruction.

Introduction

Technology in Education

In today's technology era, technological tools take place in our lives according to our needs (Akkoyunlu, 1995; OECD, 1988). The use technology in education provides students with the opportunities to reach information in every place and in a quick way (Weiser, 1999). Prensky (2005; 2006) states that today's students are so skillful that they can integrate the technology in their own learning approaches. In this sense, students' effective use of technology and communication contributes to their own understanding and their knowledge acquisition processes (Lin, 2007; van't Hooft, Swan, Cook, & Lin, 2007). Previous studies have shown that well-designed and integrated technological tools in instructional environments can have positive impacts on students' conceptual learning (Hitlin & Rainie, 2005; Lazarus, Wainer, & Lipper, 2005; Wenglinsky, 2006). van't Hooft et al. (2007) expressed that there exist a number of technological tools (calculator, computer, projector, etc.) and softwares that can facilitate to create an effective learning environment and to achieve students' meaningful learning.

It is surely beyond doubt that the changes that occur in learning and teaching environments have an impact on teaching. Thus, learning and teaching environments become more student-centered, more constructivist, and more flexible (Fung, Hennessy, & O'Shea, 1999; Norris & Soloway, 2004; Ricci, 1999; Rockman, 2003; Swan et al., 2006; Zucker & McGhee, 2005).

Students can achieve meaningful and effective learning in the learning and teaching environments, which are, appropriate their learning styles and pace (Benjamin, 2005; Kara-Soteriou, 2009; Tomlinson, 2001). The use of technology in education centers on the provision of learning according to the interest, ability, and individual characteristics of the students (Benjamin, 2005; Tomlinson, 2001; Tomlinson & Allen, 2000). In accordance with their changing interest and abilities, students need different kinds of digital tools to discover and create knowledge and to communicate (Danesh, Inkpen, Lau, Shu, & Booth, 2001; Roschelle, Penuel, & Abrahamson, 2004). This shows that technology is inevitable and required in education.

The integration of technology in mathematics classrooms helps learners in the processes of complex thinking and decision-making (McFarlane & Sakellariou, 2002). The integration of technology in mathematics instruction comes into prominence since it provides strong representations in visualization, simulation, and modelling (Kaput, Noss & Hoyles, 2008).

Technology comprises electronic devices such as computers, calculators, portable devices, and telecommunication tools and the multimedia equipment including the software of these devices (Dick & Hollebrands, 2011). Dick and Hollebrands (2011) points out that technology has two roles in mathematics classrooms as conveyance technologies and action technologies. The former includes the technological practices related to presenting and transmitting the knowledge between teachers and students. Conveyance technologies provide explanation for the knowledge to be transmitted and presented and opportunities for sharing the solutions, and they contribute to students' reasoning, understanding, and producing. These kind of technologies involve presentation tools (interactive whiteboards, slide-presentation software, document presentation), communication tools (Internet), sharing and collaboration tools (virtual environments through which people can participate in collaborative work), assessment, monitoring, and distribution tools (formative assessment, personal screen hardware) (Dick & Hollebrands, 2011). The latter includes the technological practices which enable one to perform the mathematical tasks/exercises, or to reply user's actions in mathematically defined ways. The aim of the action technologies is to bring the cases, tasks, and works which exist in nature in a mathematical way to the mathematics classrooms. These kinds of technologies involve computational/representational tool kits (e.g. calculators, computer software), dynamic geometry software virtual manipulatives, and computer simulations.

The uses of technology for simulation and visualization in the teaching of complex mathematical concepts are referred as effective instructional materials (Savage, Sanchez, O'Donnell, & Tangney, 2003; Tall, 2002). Technology provides students with the opportunity to discover mathematics through representing symbols and operations, offering dynamic representations, and visualizing the facts and complex problem cases (Kaput & Shaffer, 2002). DiSessa (2000) claimed that the integration of technology in mathematics helps teachers enhance students' huge visualization capabilities.

The use of technology by expert teachers facilitates understanding especially in the teaching of algebra and geometric mathematical concepts in all primary, middle, and high school levels (Hillel, Kieran, & Gurtner, 1989; McCoy, 1999; Pea, 2004). Besides, it is stated that the technology-integrated instructional programs promote positive development in students' learning when they are used effectively by qualifies teachers (SRI International, 2002).

The use of multiple representations in mathematical concept development helps to protect and relate the meaning of concepts (Moyer, 2001). Concept development includes students' perceptions first towards concrete objects, and then towards semi-abstract objects, and finally towards abstract objects in their perceptions of mathematical concepts (Bruner, 1960, 1986; Piaget, 1952). The studies in the literature have demonstrated that using virtual manipulatives in teaching environment facilitates students' conceptual learning and their conceptual development (Moyer, Niezgoda & Stanley, 2005; Reimer & Moyer, 2005). Reimer and Moyer (2005) carried out their study to investigate the effects of visual mathematical manipulatives including technology-based representations on the comprehension of abstract mathematical concepts. During two-week period, the researchers used virtual manipulatives in 19 primary school students' sense-making processes. The results of the comparison of pre-test and post-test revealed that the use of virtual manipulatives in mathematics instruction had positive effects on both procedural and conceptual knowledge. Technology used in mathematics instruction has significant contributions to the processes of creativity, problem solving, reasoning, and make generalization, which are accepted as the foundations of mathematics (Schwartz, 1993). Schwartz (1993) articulated that students can discover the hypotheses taking place in the process of problem posing and solving in mathematics through using their creativity as in different fields.

Polly, Mims, Shepherd and Inan (2010) put forward that there exist belief and agreement that technology has positive effects in mathematics instruction. It is also of crucial importance to note that the teacher using technology has major role regarding the positive impacts of technology on teaching (Polly et al., 2010). In other words, teachers should be equipped with sufficient knowledge and skills in order to be able to use technology in an effective way in their classrooms (International Society for Technology in Education, 2000). Similarly, Gorder (2008) states that there are a number of important factors in using technology in the classrooms in an effective way, but the most important factor among them is the teachers' competence which is required for developing instructional technology activities to meet the needs of the students. In the same vein, McDougall (1997) suggests that the appropriate infrastructure be created for the teachers to use new technologies, and the teachers be encouraged to integrate these technologies in their classrooms.

The Integration of Science and Mathematics in Mathematics Instruction

Integrated education benefits for making sense of the related concepts, which take place in different curricula (Gallant, 2010). National Research Council (NRC, 1996) asserts that science and mathematics should be integrated in order for the students to develop mathematical understanding and to use mathematics. In addition, according to Rutherford and Ahlgren (1990), it is necessary to integrate science and mathematics since, as part of the scientific research, mathematics is required for students to carry out the scientific processes (hypothesis, prediction, observation, communication, etc.). Besides, it is stated that through integrated science and mathematics education students can gain various perspectives, suggest creative ideas for the problems they encounter in daily life, and transfer the knowledge they acquire in mathematics and science courses (Beane, 1997; Kiray, 2012; Kiray & Kaptan, 2012).

Kullman (1966) believes that the students in primary and middle school mathematics classrooms where science and mathematics are integrated think and work like a mathematician. Moreover, the integration of mathematics into other subjects is important to demonstrate how mathematics is used in daily life (Mock, 1963). Furthermore, Breslich (1936) pointed out that the integration of physics, chemistry, and engineering problems in mathematics instruction increases students' competence towards mathematics. The researcher maintained that rather than traditional mathematics instruction, integrating laboratory and science activities in mathematics instruction is more effective in making mathematics more meaningful for mathematical practices in daily life (Breslich, 1936). In line with Breslich, Basista and Mathews (2002) believe that science subjects provide a rich content in order to be able to make mathematical relations and expressions more meaningful.

Besides it provides students with the operational practices through which they can develop their mathematical operational skills, the integration of mathematics and science promotes students' interest towards mathematics (Kullman, 1966). Hall (1953) found that while the students have difficulty in solving mathematical equations and formulas in science courses, they do not have any difficulty in solving the same operations in mathematics courses. This shows that the students experience difficulty in relating science and mathematics concepts and topics. However, it is stressed that integrated science and mathematics instruction exerts positive influence on the development of concept, skill, and process of the students (Berlin, 1989; Kiray, Gok & Bozkir; 2015; Milson & Ball, 1986). For instance, Furner and Kumar (2007) found that integrated science and mathematics education promotes meaningful learning and enhances students' motivation towards science and mathematics subjects. Furthermore, Blume et al. (2001) pointed out that the integration of science and mathematics has positive impacts on students' counting and problem-solving skills. Additionally, Abad (1994) expressed that the abstract representation like x, y, and z in mathematics should be presented through relating to science, and thus mathematics can be related to daily life.

On the integration of mathematics, science, and technology, International Technology Education Association (2000) states that;

> *"... Science provides the knowledge about the natural world that underlies most technological products today. In return, technology provides science with the tools needed to explore the world... Mathematics offers a language with which to express relationships in science and technology and provides useful analytic tools for scientists and engineers." (*p. 44).

It is necessary to integrate mathematics, science, and technology in performing a scientific work (American Association for the Advancement of Science, 1995). Besides, integrated education experience is required for ensuring the desired cooperation in the teaching process, conducting research and inquiry, and developing problem-solving skills (Berlin & White, 2010). Therefore, the teachers should be encouraged and trained for carrying out the integrated in-class instruction (Berlin & White, 2010).

The studies in the literature have shown that there are a number of factors in providing integrated instruction including pedagogical knowledge, pedagogical content knowledge, teachers' perceptions and beliefs, school and school administration, evaluation practices, and instructional materials (e.g. Frykholm & Glasson, 2005; Lehman & McDonald, 1988; Meier, Cobbs & Nicol, 1998). Thus, teachers' ideas about the integration of science, mathematics, and technology come into prominence to create an integrated educational environment. The present study aims to explore the views of middle school mathematics teachers on the integration of science and technology in mathematics instruction. The following research questions guide this study:

1. What are the views of the middle school mathematics teachers on the integration of various disciplines in mathematics instruction?
2. What are the views of the middle school mathematics teachers on the integration of mathematics and science topics?
3. What are the views of the middle school mathematics teachers on the integration of mathematics and technology topics?
4. What are the views of the middle school mathematics teachers on the appropriateness of the curriculum for the integration of mathematics, science, and technology?

Method

In the present study, a qualitative research method was employed which provides the researchers with the opportunity to carry out in-depth examination (Bogdan and Biklen, 1998; Richardson and Ginsburg, 1999). Richardson and Ginsburg (1999) define that is conducted in natural settings and, it provides opportunity to understand a social and personal phenomenon through complex and holistic approach and to investigate a phenomenon from different perspectives".

This study employed a case study model which is one of the qualitative research methods. Case study model believed to be appropriate for the investigation of special phenomena in a certain context (Creswell, 2008; Merriam, 2001). Case studies involve in-depth investigations related to certain phenomena in education such as program, person, process, and social group (Merriam, 1988). It is of crucial to determine the boundaries of the case to be examined (Creswell, 2008; Hatch, 2002; Yin, 2009). Since this study aims to explore the views of the middle school mathematics teachers about the integration of science and technology in mathematics education, case study method was used. The process of qualitative case studies includes the stages of data collection, organization, and data analysis and, at the end of the this process the results related to a special situation are obtained (Patton, 2002).

Study Group

The present study was carried out in the spring term of the 2015/2016 academic year. A total of 12 middle school mathematics teachers from randomly selected 4 different middle schools participated in the study. All of the participants were voluntary to take part in the study. The participants were selected through maximum variation sampling method that is one of the purposive sampling methods. The selection of the participants was based on several criteria such as to work at different schools, to have different years of service (experienced-inexperienced), and to teach at different and common class levels regarding middle school mathematics course.

The aim of this method is not to make generalizations through providing variation, but to find out the similarities among various cases (Yıldırım & Şimşek, 2008). In this study, teachers' having different years of service provides opportunity to explore the differences and similarities with respect to the integration of science and technology in mathematics education by experienced and inexperienced teachers, and the class levels in which teachers work assist to reveal the integration level used at different and same class levels.

The interviews were planned to be conducted in a quiet environment and therefore the assistant directors' rooms were used. The researchers stuck a note on the doors showing "interview is being held". After the participants had been informed that the interviews were related to the integration of science and technology in mathematics education, that it would take approximately 20-30 minutes, the collected data would be confidential, each of 12 participants was interviewed through a semi-structured interview. Pseudonyms were given to the 12 participants in order to ensure their privacy in the form of T1, T2, …, and T12. The demographic information is presented in the Table 1.

The Table 1 indicates that the participants of the study comprise of 3 female teachers and 9 male teachers. Regarding the teaching experience of the participants, 2 participants have 1-5 year, 2 participants have 6-10 years, 6 participants have 11-15 years, and 2 participants have 15-20 years. Regarding the undergraduate departments of the participants, 2 participants graduated from Faculty of Arts and Sciences Department of Mathematics, 1 participant graduated from the Department of Classroom Teaching, and 9 participants graduated from Faculty of Education Elementary Mathematics Education. The teachers graduated from Faculty of Arts and Sciences Department of Mathematics participated in a teaching certificate program, and they took their teaching certificate to work as mathematics teachers in middle schools. The teachers graduated from Faculty of

Education Department of Classroom Teaching completed a double major in their undergraduate period (Department of Elementary Education and Elementary Mathematics Education), and due to the fact that the application of new education system (4+4+4) in Turkey brought about excessive increase of the number of classroom teachers, these teachers were employed as mathematics teachers.

Table 1. Teachers' gender, teaching experience, and graduated department

Teacher (Gender)	Teaching Experience (Year)	Undergraduate Program	Grade Level
T1 (M)	14	Faculty of Arts and Sciences Department of Mathematics	7th and 8th Grade
TT2 (F)	5	Faculty of Education Elementary Mathematics Education	5th, 6th, and 7th Grade
T3 (M)	1,5	Faculty of Education Elementary Mathematics Education	7th and 8th Grade
T4 (M)	8	Faculty of Education Department of Classroom Teaching	5th and 6th Grade
T5 (M)	11	Faculty of Education Elementary Mathematics Education	7th and 8th Grade
T6 (M)	13	Faculty of Education Elementary Mathematics Education	6th and 8th Grade
T7 (M)	18	Faculty of Education Elementary Mathematics Education	7th and 8th Grade
T8 (F)	15	Faculty of Arts and Sciences Department of Mathematics	5th, 6th, and 7th Grade
T9 (F)	14	Faculty of Education Elementary Mathematics Education	5th and 6th Grade
T10 (M)	10	Faculty of Education Elementary Mathematics Education	6th, 7th, and 8th Grade
T11 (M)	14	Faculty of Education Elementary Mathematics Education	6th Grade
T12 (M)	16	Faculty of Education Middle Mathematics Education	6th and 7th Grade

The middle school mathematics teacher' educational background related with the integration of science and technology in mathematics instruction was also investigated**.** It was found that while the teachers received training in various degrees regarding technology use, they did not have any training on science field. The training the teachers received and their contents were shown in the Table 2.

Table 2. The middle school mathematics teachers' training on the integration of science and technology in mathematics instruction

Education Field	Education Type	Content	Participants
Technology	In-service training seminars	Use of Smart Board	T1, T4, T7, T8, T10, T12
		GeoGebra	T2
		Cabri	T2
		Material Development	T11
	Undergraduate education	Material Development	T5
		GeoGebra	T3
	Workshops	Programming	T5, T9
	Projects	Use of Technology	T11
Science	-	-	-

It is clear that the training the middle school mathematics teachers received was related to only technology integration, and the teachers do not have any training on science integration in mathematics instruction. The results of the interviews revealed that the teachers received education on technology integration through in-service training seminars, undergraduate education, workshops, and projects. The content of the education they received is comprised of use of smart board (Antropi Teach Programme), GeoGebra, Cabri, and material development.

It was found out that except for T2, T6 teachers received in-service training only for the use of smart board regarding technology integration. There are only 3 teachers who received education through workshops and projects. It appears that with respect to the integration of technology in education the participants received in-service training mostly on the use of smart board. The participants articulated that they did not receive adequate education on the integration of technology in mathematics instruction. It was observed that when the teachers are equipped with adequate skills through appropriate training, they are willing to use technology in their classrooms.

Data Collection Instrument and Data Analysis

The researchers developed a semi-structured interview form to collect the data. In the process of developing the interview form, the related studies on the integration of science and technology in mathematics instruction in the literature have been examined (e.g. Duhaney, 2001; Niess, 2005; Herro & Quigley, 2016; Songer & Linn, 1991). Next, in line with the examined studies, a draft interview form was prepared, and the form was reviewed by two faculty members from mathematics and science education field who have several studies on mathematics and science instruction. Finally, in light of experts' feedback on mathematics and science content, the interview form was revised. The questions in the form targeted to explore in-depth information about the teachers' educational background, their years of teaching experience, their undergraduate programs, and their training on the integration of science and technology in mathematics instruction.

The interview form includes the following questions:

- Did you have any training on the integration of science and technology in mathematics instruction? If yes, please specify.
- What are your opinions and views on the relationship between mathematics instructions with different disciplines?
- What are your opinions and views on the integration of science and mathematics topics?
- What are your opinions and views on the integration of technology in mathematics instruction?
- What are your views on the appropriateness of the curriculum for integrating science and technology in mathematics instruction?

In qualitative research, from point of view of the variability of the events and cases, the reflection of this variability is known as internal reliability (Lincoln & Guba, 1985). To examine the consistency of the study, it is suggested to apply an external person. In the present study, the researcher attempted not to involve her personal views as much as possible in the study, and tried to approach the study as an external observer. To ensure the confirmability in a study, it is required to involve an external expert opinion or to compare the data collected through using several data collection tools. In this study, an external observer examined the data to enhance the confirmability of the study.

The semi-structured interviews conducted with teachers took approximately 40 minutes. Each interview session audio recorded with the permission of the participants. In order to conduct the interviews in a quiet environment, the director and assistant directors' rooms were used. Then, the audio recorded interviews were transcribed, and the researchers started to analyze them. The researchers adopted content analysis method in order to analyze the data. The major aim of the content analysis method is to reach the concepts and relations which can explain the gathered data (Yıldırım & Şimşek, 2008). To do so, the data were coded according to common features, and the common coded were listed under each other. In doing so, the responses of the teachers were coded around common features and these common coded listed under each other. Finally, the generated codes were grouped under categories by their conceptual features and presented in tables. To support the generated codes and categories in a descriptive way, the researchers included some excerpts from participants' responses. For example, for the first research question, the categories obtained are "Mathematics is related to different disciplines" and "Mathematics is not related to different disciplines". The codes involved in the category of "Mathematics is related to different disciplines" are "science", "social science", "music", and "art".

Results

This part includes, middle school mathematics teachers' views on the integration of various disciplines, science and technology into mathematics education and middle school mathematics teachers' views on the appropriateness of the mathematics curriculum for the integration practices were presented under related research questions respectively.

What are the views of middle school mathematics teachers on the integration of different disciplines into mathematics education?

The views of mathematics teachers on whether mathematics education is related with different disciplines were coded, and the disciplines the teachers considered as related with mathematics were classified with different codes. These categories and codes were shown in Table 3.

Table 3. The related disciplines to mathematics education

Category	Code		Participants
Mathematics is related to different disciplines	Science	Physics	T1, T2, T5, T6, T7, T8, T10, T11, T12
		Chemistry	T5, T7, T8
		Biology	T8
	Social Sciences		T2, T6, T10
	Music		T8
	Art		T2
Mathematics is not related to different disciplines	-		T3, T4

According to the findings in Table 3, the majority of teachers agreed that mathematics can be related to a number of disciplines. It is clear that mathematics is believed to be related mostly to science (physics, chemistry, and biology) among other disciplines. Several teachers expressed that mathematics can be related to social sciences such as geography, and visual arts such as music and art. The excerpts from the participants T2, T4, and T7 were shown below;

> T2: *… I give examples from different disciplines; I relate integers with temperature, the perspective topic is related to art, for example. Previously, it took place in our teacher guide books as "relate this topic to these in social studies" and "relate this topic to this in science". Now, we do not have a guide book, which is another problem.*
> T4: *Other disciplines have much more necessity for mathematics, but we rarely relate mathematics to other disciplines. We do not need to integrate other disciplines in mathematics. For example, for the speed problems topic, we say that you will encounter this topic later in science, but I think this does not mean we integrate science in mathematics.*
> T7: *I think mathematics is related to physics and chemistry, but not with others.*

According to another finding obtained from interviews, 2 participants (T3, T4) believe that mathematics is not related to other disciplines. It is noteworthy to mention that these 3 teachers graduated from faculty of education, and this relationship was stressed via a number of courses and concretized with the help of examples throughout their undergraduate education. The excerpts from these teachers were presented below;

> T3: *Actually, mathematics does not require much to use other disciplines, rather other disciplines use mathematics much. Since it is already a hard work to teach mathematics, it is not that appropriate to integrate other disciplines, I think.*
> T4: *Mathematics is an essential discipline. That is, it is basis for other disciplines. Therefore, regarding other disciplines, I think mathematics is essential, but it is not necessary to integrate other disciplines in mathematics.*

What are the views of middle school mathematics teachers on the integration of mathematics and science topics?

In the analysis of the interviews conducted with mathematics teachers, their views on the integration of science in mathematics instruction were categorized as "positive and negative views", "the views on integrability", and "the views on the topics that can be integrated" and the related codes were determined.

The first category related to positive and negative views on the integration of science in mathematics instruction and the related codes were shown in Table 4. The positive and negative views were classified and categorized as concretization and relating to daily life. The "positive" category includes the views that show the integration of mathematics and science can be achieved, while the "negative" category is related with the views that show the integration of mathematics and science cannot be achieved. Under the code of "concretization" the statements related to "concretizing mathematics and visualization" were involved. As for the code of "relating to daily life", it includes the cases which can be experienced in daily life.

The excerpts related to this category were shown below;

> T2: *Sometimes the students cannot think math in an abstract way. Regarding this problem, relating mathematics to other disciplines can be useful. For example, the teacher can give the example of slope*

in science when he/she teach trigonometry in mathematics. In this way, it can increase students' interest, and the students can rationalize the topics.
T6: I think especially memorability and visualization can be effective in concretizing the abstract concepts in mathematics. In this way, students become more active, rather than one-way teaching method. As for negative side, some students may not comprehend it; some students cannot think about different topics because they do not comprehend mathematics.
T5: *In science, known as life itself, there are lots of topics that can be encountered in daily life. Related to these topics, the teacher can mention mathematics topics. I can use science problems in the warm-up stage of the mathematics course especially for attracting the students' attention.*

Table 4. Positive and negative views on the integration of science in mathematics instruction

Category	Code	Participants
Positive	Concretization	T2, T6, T7, T11, T12
	Relating to daily life	T5
Negative	The necessity of the integration of mathematics in science instruction rather than the integration of science in mathematics instruction	T1, T8
	Debilitating teaching	T4, T9
	Nonnecessity of the Integration	T3, T10

The negative opinions of the teachers regarding the integration of mathematics and science include the codes as debilitating teaching and the necessity of the integration of mathematics in science instruction rather than the integration of science in mathematics instruction. The views related to different categories can be seen below;

T1: *Of course, mathematics is essential in science instruction; it is a must to know mathematics in numerical calculations in physics, for example. However, ı think science has middle place in mathematics instruction when compared to science.*
T3: *There are some topics in which science and mathematics can be integrated, but I think they are not many. For example, it is too hard to teach pressure in mathematics. In fact, students have difficulty in mathematics; when we integrate the subjects, it creates more troubles for students. They are already unable to think analytically; it is actually more challenging for students to understand with different topics. It may wok in successful classrooms.*
T9: *… The integration can be employed for just giving examples. When we integrate completely the subjects in instruction, the students get confused. In fact, they already have difficulty in comprehending the mathematics topics.*

Another category generated from the views on the integration of science in mathematics instruction is "the requirements for the integration of science in mathematics instruction"**.** The codes obtained from this category are presented in Table 5.

Table 5. The requirements for the integration of science in mathematics instruction

Category	Code	Participants
It can be integrated and no requirements are needed	Giving example	T1, T2, T5, T7, T8, T11, T12
It can be integrated if the requirements are met	Teacher training	T3
	Students' level	T6
	Parallel curriculum	T9
It cannot be integrated	-	T4, T10

Under the category of "It can be integrated", the code of "giving example" involves the sample cases in which mathematical concepts are used in science and the cases from science which can be integrated with related mathematical topics. The codes under the category of "It can be integrated if the requirements are met" include teacher training (teachers should be trained), students' level (students should have adequate level of knowledge and skills), and parallel curriculum (science and mathematics courses should be taught concurrently).

The participants T1, T11, and T12 agreed on the integration of science in mathematics instruction through giving examples from science. The excerpts of these teachers are as follows;

> T1: *For example, there is ratio with units in 6th graders. This topic is encountered as km/h in force-motion topic in science as the ratio of the distance a car travels to time.*
> T11: *For example, we use the integers in heat-temperature topic, and we use thermometer to indicate increase and decrease. For ratio and proportion topic, mixtures and speed and time topics in science can be used.*
> T12: *... We watched the video of a diver who dives into the sea to teach negative numbers. I asked such questions as "how deep the diver dived", did the depth increase, etc. to make the students comprehend the topic.*

Regarding the requirements of the integration, the participants T3 and T9 who do not have positive views on the integration of mathematics and science articulated that there should be certain requirements for integration. They have the following views;

> T3: *For the integration, mathematics teachers need to be knowledgeable about science topics, as well. Before the course, teachers need to prepare and think the topics that can be integrated. Teachers cannot integrate the topics in instruction without any preparation.*
> T6:*... For the integration of the subjects, the students should have certain achievement levels. Since the low achievement students have difficulty in understanding mathematics, they cannot relate the integration of subjects.*
> T9: *The science topics cannot be direct included in mathematics instruction, but the topics of science and mathematics can be arranged in curriculum to be taught in parallel. Science and mathematics teachers can decide together…*

The participants T4 and T10 who do not integrate the subjects during the instruction and who have negative views on the integration have expressed that there is no way for the integration of science in mathematics instruction. Related to this, their excerpts are as follows;

> T4*: …It is not necessary to integrate science in mathematics, I think. This kind of aim should not be the case in mathematics instruction…*
> T10: *Since the curriculum is exam-oriented, it can be meaningless for the students to include such kind of integration practices…*

Another category obtained from the general views on the integration of science in mathematics instruction is "science and mathematics topics that can be related to the integration of science in mathematics instruction".

The science and mathematics topics considered to be related and integrated are presented in the Table 6.

Table 6. The related mathematics and science topics

Category	Code		Participants
	Mathematics	Science	
There are related topics	Integers	Heat-Temperature	T5, T8
	Ratio-Proportion	Force and Motion	T1, T2, T3, T4, T5, T6, T8, T9, T10, T11
		Mixtures	T5, T8
		Electric	T8
	Probability	Genetics and Heredity	T8
There are not any related topics	-	-	T7, T12

The majority of the teachers stated that there are certain science and mathematics topics that can be related. According to the Table 6, two participants articulated that the integers topic in mathematics is related to heat and temperature topic in science. 10 participants believed that ratio and proportion topic in mathematics is related to force and motion, mixtures, and electric topics in science. It is clear that the majority of teachers related ratio and proportion topic in mathematics with science topics. It is also pointed out that there are probability and genetics and heredity topics among the related science and mathematics topics.

> T1: *For example, there is ratio with units in 6th graders. While teaching this topic, I express that you can come across this in science as km/h in force and motion topic.*

For instance, for the ratio and proportion in mathematics, force and motion, electrical circuits, and/or mixtures in science can be shown as examples. Again, while stating the probability of being brown or blue-eyed in science, the teacher can include probability from mathematics. In addition, while teaching negative and positive integers, the teacher can give thermometer and/or heat and temperature topics as examples.

The table shows that the participant T7 and T12 do not believe that there are science and mathematics topics that can be related each other in education. Regarding this belief, the excerpts are as follows;

T7: … *I think there are not many mathematics topics that can be related to science topics in middle school curriculum; there may be more topics in high school curriculum.*
T12: *Mathematics is not that much related to science. Of course, science cannot be science without mathematics, but still there are not that many things related to science.*

What are the views of the middle school mathematics teachers on the integration of technology in mathematics classrooms?

The data obtained from the semi-structured interviews were categorized as the general views of the teachers on the integration of technology in mathematics instruction, positive/negative views, the aim of the integration, the technological materials used for the integration, and the views on the topics that can be integrated, and the codes related with these categories were determined.

The positive/negative views generated from the views of the teachers on the integration of technology in mathematics instruction were coded, and the positive ones classified and coded as time-saving, concretization,/visualization, providing the opportunity to use different materials, facilitating teaching, and the opportunity to study out-of-class. As for the negative views, they were coded as undermining instruction and lack of infrastructure.

Table 7. The positive/negative views on the integration of technology in mathematics instruction

Category	Code	Participants
Positive	Time-saving	T1, T11, T12
	Concretization/Visualization	T1, T3, T5, T6, T7, T9
	Providing the opportunity to use different materials	T2
	Facilitating teaching	T4
	The opportunity to study out-of-class	T10
Negative	Undermining instruction	T12
	Lack of infrastructure	T5, T8

The Table 7 shows that the majority of teachers have positive views on the integration of technology in mathematics instruction. The excerpts of the teachers who have positive views can be seen below;

T3: *It is difficult to draw geometric shapes on the board such as fractals or reflection/rotation. It is difficult to teach these through drawing. Therefore, the smart boards make it easy to visualize the shapes that are difficult to be drawn.*
T4: *When the students have difficulty in understanding some points, we watch videos or animations since these kinds of things are easy to comprehend visually. However, we use the smart board only for saving time in solving mathematics problems rather than for teaching the topic.*

The participants T8 and T12 who have negative views on the integration of technology in mathematics instruction uttered that;

T8: *If the infrastructure is established, we can use the smart board effectively. However, we have some problems such as there is no Internet connection, it takes time to connect during the course, and the students cannot use their tablets properly.*
T12: *There should be some problem solving periods in mathematics. I use the smart board to make it easy to visualize, but the students just watch it. I do not believe that we can teach mathematics effectively through smart boards. How can the students make revisions at their homes without writing down anything?*

The Table 8 presents the codes generated under "the aim of the integration" category which obtained from the general views of the teachers on the integration of technology in mathematics instruction.

Table 8. The aim of the technology integration in mathematics instruction

Category	Code	Participants
The aim of the technology integration	Solving mathematics problems	T1, T3, T7, T11, T12
	Visualizing the geometric objects	T1, T4, T7, T9
	Watching video	T1, T2, T4
	Simulation	T4
	Homework	T10

In order to determine the aims of the teachers who use technology in their classrooms, the views of the teachers were classified through codes in Table 8. These codes are solving mathematics problems, visualizing the geometric objects, watching video, simulation, and homework.
The excerpts of the participants are as follows;

> T1: *In general, I use for solving mathematics problems. I hand out problem sheets to students, and I use smart board to reflect the problem on the screen in order to prevent loss of time due to drawing or writing the problem on the board. Sometimes, we watch videos on the lives of scientists in order to attract their attention.*
> T4: *Regarding technology use, I use smart board. I make use of tablets, PCs/laptops, animations and so on since visualization is important in mathematics. They are useful especially for concretization of the geometric objects. I make effort to use the animations of EBA, Morpa Campus, Vitamin, etc.*
> T7: *While teaching the geometric objects, it is not always possible to visualize and concretize these objects such as rotation and getting symmetry in fractals, and thus I make use of technology. The use of technology is useful for these kinds of geometry topics.*
> T10: *There is an application in EBA to be used by teachers. Through using that application, I assign students' homework, and the students send their homework back to me after they finish it. The students like this kind of homework assignments through technology use.*

Another category obtained from the general views of the teachers on the integration of technology in mathematics instruction is "the technological materials used for the integration". The determined codes and sub-codes related to this category are presented in the Table 9.

Table 9. The technological materials used in instruction

Codes	Sub-codes	Participants
Computer	EBA (EIN)	T1, T2, T4, T5, T7, T10
	Morpha Campus	T4
	Vitamin	T4
	GeoGebra	T3
Smart Board	Antropi Teach	T1, T2, T3, T4, T7, T9, T10, T11, T12

Regarding the variety of the technological tools and materials middle school mathematics teachers used in their classrooms, it appears that the majority of the teachers make use of smart board and Antropi Teach, an application of smart board. Besides smart board, it is clear that teachers use computers, software, program, and interactive instructional materials as technological tools. These include such programs as EIN (Educational Information Network), Morpha Campus, Vitamin and GeoGebra.

It is seen that although middle school mathematics teachers received Information and Communication Technologies Assisted Mathematics Instruction course in which they were trained on the use of GeoGebra and preparation of activities in their undergraduate program, the teachers did not use this program. Similarly, even though the teachers were given the right to use smart board and Antropi Teach program as well as EBA (EIN) which includes a number of interactive software, videos and presentations, web sites, and instructive games, it is clear that the teachers do not use these.

The last category generated from the general views of the teachers on the integration of technology in mathematics instruction is "the mathematics topics in which the technology integration in mathematics instruction is effective". The codes related to this category are shown in the Table 10.

Table 10. The mathematics topics in which the technology integration in mathematics instruction is effective

Code	Participants
Fractions	T9
Geometric Objects	T1, T3, T9
Equality and equivalence	T8, T9
Transformational geometry	T7, T9
Fractals	T7
Patterns	T4

The Table 10 shows the topics for which the teachers make use of technology in teaching mathematics. It is clear from the Table 10 that technology is used for the geometry topics which require visualization and concretization. In addition, for the topics including fractions, congruence and similarity, and patterns the teachers integrate technology in mathematics instruction.

What are the views of the middle school mathematics teachers on the appropriateness of the curriculum for the integration of mathematics, science, and technology?

The views of the teachers on the appropriateness of the curriculum regarding the integration of science and technology in mathematics instruction were coded. The views on the inappropriateness of the curriculum for the integration classified as abundance of topics, lack of time, mainstream exams (Transition from Primary to Middle Education), and disregarding the effectiveness of the relating skill involved in the curriculum.

Table 11. The views on the appropriateness of curriculum regarding the integration of science and technology in mathematics instruction

Category	Code	Participants
Appropriate	-	T4, T5
Inappropriate	Abundance of topics	T9
	Lack of time	T2, T3, T8
	General exams	T6, T10, T11, T12
	Insufficiency of relating	T1, T7

The excerpts of the participants T4 and T5 who support the idea that the curriculum is appropriate for the integration of science and technology in mathematics instruction are as follows.

> T4: *Previous curriculum was too dense, but this curriculum is appropriate for the integration, I think. The curriculum of the 5th, 6th, and 7th graders is very appropriate to make activities, and use technology, etc.*
> T5: *I think the curriculum is appropriate. Due to the fact that we have not been trained yet through the FATIH ((*Movement of Enhancing Opportunities and Improving Technology) *Project, we are unable to use technological materials. If we had been trained, we could have use technology in mathematics instruction.*

10 participants believed that the curriculum is inappropriate for the integration. The determined codes were abundance of topics, lack of time, mainstream exams, and insufficiency of relating. Some of the excerpts are as follows;

> T1: *The necessity of the relating skill was explained too briefly. It is not applicable. There is a continuous instruction, and thus I do not involve.*
> T3: *I think it is more appropriate to include these kinds of different things in elective courses like "mathematics practices". Since there is no enough time, we have difficulty in finishing the topics on time.*
> T11: *Since we are generally exam-centered, we devote more time for solving problems rather than for these kinds of things.*

Discussion, Conclusion, and Implications

In this study, the views of the middle school mathematics teachers on the integration of science and technology in mathematics instruction have been presented under the following sub-titles; the training the middle school mathematics teachers received on the integration of science and technology in mathematics instruction, the integration of different disciplines in mathematics, the views on the integration of science and technology in mathematics instruction, and the views on the appropriateness of the curriculum for the integration practices. The results of this study are discussed in this part.

The findings of the study showed that middle school mathematics teachers did not receive any education (in-service training, undergraduate education, etc.) on the integration of science in mathematics instruction. In the related literature, it is stressed that teachers' lack of or insufficient knowledge towards both their own fields and the discipline to be related cannot allow proper integration (Frykholm & Glasson, 2005; Kıray & Kaptan, 2012; Lehman and McDonald, 1988). Similarly, Mason (1996) claimed that teachers' lack of knowledge for the integration can cause both some problems in interdisciplinary integration practices and improper instruction. This situation has negative impacts on students' learning in both disciplines (Frykholm & Glasson, 2005; Kiray, Gok & Bozkir, 2015; Kiray, 2010). Therefore, mathematics teachers should be trained on the integration of science and mathematics through pre-service and in-service training programs, projects, workshops. Likewise, it stated that the courses, projects, and other education opportunities prepared for the integration of science and mathematics exert positive influence on the views and opinions of the teachers towards the integration (Koirala & Bowman, 2003; Lonning & DeFranco, 1994; Wicklein & Schell, 1995). It is suggested that middle school mathematics teachers be trained on the integration of science and mathematics during their pre-service and in-service education through in-service training programs, projects, and workshops.

In a number of studies carried out to examine the scientific nature of mathematics and for the integration it was suggested that the integration of mathematics and science be promoted (e.g. Berlin, 1991; Berlin & White 1994; Davision, Miller & Metheny, 1995; Kellough, 1996; Lonning & Defranco, 1997; Huntley, 1998). With respect to the disciplines which can be made use of and integrated in mathematics instruction, the majority of the teachers agreed that science (physics, chemistry, and biology) fields are appropriate to integrate in mathematics instruction. Lehman (1994) found that elementary school teachers supported the integration of science and mathematics in instruction. In contrasts to this finding, some teachers involved in the same study believed that mathematics was not related to other disciplines. In some studies, it was stressed that teachers' inadequate content knowledge prevents the integration of science and mathematics (e.g. Basista & Methews, 2002; Frykholm & Glasson, 2005; Lehman & McDonald, 1988; Mason, 1996; Huntly, 1998). Similarly, in Frykholm and Glasson's (2005) study, the teachers were aware of the integration of science and mathematics and its importance, but due to their inadequate content knowledge and lack of experience, they hesitated to practice. Hence, teacher training on the nature of mathematics and other disciplines and on the content and pedagogical knowledge for the integration of mathematics and science becomes prominent.

Bassok and Holyoak (1989) emphasized the effect of teaching conducted from concrete to abstract and pointed out following the teaching abstract concepts in mathematics these concepts can be concretized in science. In the same vein, Kaminski, Sloutsky and Heckler (2006) focused on the effect of the integration of abstract mathematics with concrete science in teaching. Again, in this study the teachers had positive views on the integration of science in mathematics instruction such as concretizing the mathematical abstract concepts and using mathematics in daily life. In Basista and Mathews's (2002) study it was claimed that science provides rich content in concretizing the mathematical relationships and connections, and thus these related information provides accurate and reliable knowledge in students' mind. In literature, it is accentuated that the abstract concepts and topics in teaching can be concretized thanks to the integration of science and mathematics (McBride & Silverman 1991; Roth, 1993). In this study, it was revealed that among other views of the teachers on the integration of science and mathematics, it is considered more necessary to integrate mathematics in science and the necessity of integration of mathematics in science education accordingly. One of the finding of Watanabe and Huntly's (1998) study echoes this finding. In their study conducted with science and mathematics instructors on the integration of science and mathematics, while the science instructors perceived mathematics as a tool for science, the mathematics instructors regarded science as context for solving mathematics problems. One of the findings obtained from present study. The negative views of the teachers on science and mathematics integration is that it is not necessary to integrate science and mathematics. However, in the curriculum, MoNE (2013) accentuates the importance of relating mathematics within itself, to other disciplines, and to daily. In fact, it was asserted that the classes in which science and mathematics are integrated exert positive impacts on the success of students (Judson & Soweda, 2000; Mupanduki, 2009; Westbrook, 1998). The conducted studies put forward that the instruction with the integration of science and mathematics enhances students' interest and motivation towards science and mathematics classes (Blume et al., 2001; Furner & Kumar, 2007; Watanabe & Huntley, 1998) and contributes to data collection, data analysis, and the development of drawing and reading graphics skills (Cohen, Hillman & Agne, 1978; McDermott, Rosenquist, & van Zee, 1987). The importance of the integration of science and mathematics which is effective on student achievement, concept teaching, and skill acquisition should be emphasized in pre-service and in-service training programs, and in this way the teachers can gain both affective and cognitive skills.

Regarding the views on how it can take place the integration of science in mathematics instruction, one can benefit from the sample cases involved science. For instance, it is exemplified that teachers can integrate the integers from mathematics curriculum with heat and temperature from science, ratio and proportion from mathematics with force and motion, mixtures, and electric from science, and probability from mathematics with genetics and heredity from science. This finding is line with the study carried out by Douville, Pugalee and Wallace (2003) on the views of the teachers regarding science and mathematics topics that can be integrated. Similarly, Friend (1985) stated that the 7th grade mathematics topics that can be integrated with science include exponential numbers, square root, ratio and proportion, measurement, and reading graphics. Regarding the class levels that the teachers teach, it is seen that the teachers teach at almost all class levels. However, it was determined that the teachers touched upon few mathematics topics even if the topics were appropriate for the integration of science and mathematics, and did not use exponential and root numbers and the topics related to statistics as examples.

One other view discussed in the study is about the integration of technology in mathematics instruction. It was found out that regarding the trainings for the integration of technology in mathematics instruction, the teachers participated in various in-service training. The training that the teachers had on the use of technology in mathematics instruction was based on the use of smart board within the FATIH Project. Besides, it was determined that some teachers took part in the trainings based on interactive geometric software like GeoGebra and Cabri. The teachers who did not involve in in-service training programs were informed somewhat on the integration of technology in instruction through “material development and use in mathematics education” course in their undergraduate education. Moreover, the majority of teachers graduated from mathematics teaching undergraduate program. In this program, there is “information and computer assisted in mathematics instruction” course as either elective or required. Within the scope of this course, students are trained on how to use computer technology programs in mathematics education. Still, it was revealed that the teachers use only EBA (EIN), Morpha Campus, Vitamin, and GeoGebra rarely as technological tools in mathematics instruction. The conducted studies pointed out that the teachers need training to have adequate knowledge and skills on technology use in the classrooms (Fendi, 2007; Hardy, 1998; Lin, Hsiech & Pierson, 2004; Paprzychi, Vikovic & Pierson, 1994; Teo, 2008). Thus, it is thought that even though the teachers received training during their undergraduate program, through additional pre-service and in-service training programs on effective use of technology in mathematics instruction, it can be promoted teachers’ competence and attitudes.

Russell et al. (2003) found that the views the teachers have towards the importance of technology play a determinant role in integrating technology in their classrooms. In their study, it was revealed that the teachers had positive views on the integration of technology during instruction. Likewise, in the present study the middle school mathematics teachers believed that the mathematical abstract concepts can be concretized and visualized through the integration of technology. It is indicated that the mathematics topics the teachers tend to integrate technology in mathematics instruction are comprised of “geometric objects, congruence and similarity, and transformational geometry”. Previous studies (Artigue, 2000; Hazzan & Goldenberg, 1997; Jonassen & Reeves, 1996; Laborde, Kynigos, & Strasser, 2006; Lesh, 1990; Kaput, 1992) revealed that the use of technological tools, materials, and software concretizes the concepts and ensures meaningful learning in the process of mathematics and geometry teaching which includes abstract concepts. The integration of information and communication technologies in mathematics instruction provides in-depth learning and allows transferring mathematics to daily life (Hakkarainen et al., 2000; Tubin et al., 2003).

As for the aims of the teachers who integrate technology in their classrooms it is seen that they use technology in solving mathematics problems and visualizing the geometric objects. The teachers employ technology to solve problems since it saves time. In fact, this finding indicates that the teachers do not integrate technology in mathematics instruction in an effective way, but rather they make use of technology as a tool. This brings to mind teachers’ competence on pedagogical technological content knowledge. In contrary to this finding, MoNE (2013) and NCTM (2000) stressed that the function of the technology integration in mathematics instruction should be to make use of the information and communication technologies properly and effectively. Similarly, Hughes (2005) suggested that technology integrated in instruction be supported pedagogically by the teachers.

Hence, the technological materials used for instruction should be made use of through supported by knowledge and skills targeted to be acquired, objectives, teaching methods and strategies.

On the other hand, the availability of technological tools and materials, the infrastructure of school, and adequacy of equipment influences teachers' usage of integration of technology in their classrooms (Hall, 2008). Under the FATIH Project, along with the extensive use of smart boards in the schools the teachers participated in the in-service training programs for the use of Antropi Teach program. In this way, it appears that a great number of teachers have knowledge about this program. Another program the teachers use is EBA (Educational Information Network). It is seen that when the teachers are asked about the technological tools, materials or models they can use in mathematics instruction, the responses mostly are computers and/or smart boards. Therefore, in order to ensure the material diversity in technology use the teachers employ in mathematics instruction the teachers can be trained and equipped with the knowledge of various and effective software, programs, simulations, and interactive software. Apart from ready-made technological materials, the teachers can be provided with the opportunities to develop technological materials and models according to their own needs.

In the present study, the teachers believe that it is appropriate to integrate science and mathematics since the number of topics and objectives were reduced in the middle school mathematics curriculum (5th, 6th, 7th, and 8th graders). On the other hand, some teachers have the idea that the curriculum is inappropriate for the integration due to lack of time because of density of the curriculum, and mainstream exams. The disagreement among teachers on the appropriateness of the curriculum may be attributed to their assessment of classrooms in different levels. While the MoNE (2013) mathematics curriculum which is renewed and simplified regarding topics is used in the 5th, 6th and 7th graders, the MoNE (2005) mathematics curriculum in which the topics are denser is employed in the 8th graders. Therefore, the density of the topics in the 8th graders and the mainstream exams may restrict the integration of technological materials in instruction. According to MoNE (2013), among the anticipated skills to be attained, there exist relating skill between information and communication technology and mathematical skills in "The Curriculum for Middle School Mathematics Course". In this program, among the goals of mathematics education, it was stressed that the students be encouraged to use information and communication technologies in mathematics instruction effectively and relate mathematical concepts with daily life and other disciplines (MoNE, 2013). Information and communication technologies includes the use of sources such as calculator, spreadsheet, dynamic geometry software, website, application, animation and video. Relating skill refers to relating certain mathematics topics with other mathematics topics (e.g. ratio-proportion and equivalence), with daily life, and with sub-disciplines. Thus, it comes into prominence to integrate science courses which can be related with mathematics conceptually and operationally and as well as with daily life. However, the findings of the present study revealed that the middle school mathematics teachers both are inadequate regarding the use of technological tools and relating and do not have enough knowledge on the importance of the issue.

It is clear that there are differences among the teachers who took part in the study group regarding their years of teaching experience. According to the findings of this study, there is no relationship between teachers' teaching experience (experienced-inexperienced) and their views (positive-negative) with respect to the integration of mathematics and science. However, it was revealed that the teachers with 13 and over years of teaching experience had negative views on the integration of technology in mathematics instruction. This finding shows that new graduate teachers are more prone to using technology in their classrooms. On the other hand, although some of the teachers have positive views on technology integration, they do not integrate technology in mathematics instruction effectively. It is also found out that the teachers working at different schools but same class levels differ in science and technology integration. Still, the common point of the majority of teachers is that due to especially the TEOG (Transition from Primary to Secondary Education) exam in 8th grade, they are exam-centered and do not show diversity like integration.

The content knowledge, pedagogic knowledge, and technological knowledge of teachers impact on their usage of the technological tools instructional environments (Nelson, Christopher, Mims, 2009). Therefore, the teachers can be equipped with adequate knowledge of technology use through involving the practices for the integration of technology in mathematics classrooms and instruction in pre-service and in-service training programs.

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