Middle School Science and Mathematics Teachers' Views on Science-Mathematics Integration[1]

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Abstract

This study was conducted to determine the opinions of middle school science and mathematics teachers about science-mathematics integration. A total of 38 teachers (19 science teachers, 19 math teachers) participated in this qualitative research. Data were collected using a semi-structured interview form. The data were evaluated with descriptive and content analysis in qualitative analysis. While all of the science teachers included in the study thought that integration was necessary, mathematics teachers expressed different opinions. While the teachers had different definitions of integration, it was determined that they generally exchanged ideas with the other branch teachers. It was determined that the most course needed integration for mathematics teachers was the Turkish and the mathematics for science teachers. According to teachers, the most important advantage of integration is that it increases student course success. As a result; although science and mathematics teachers have heard about the integration of science and mathematics, they do not have sufficient knowledge and application. For this reason, it is recommended that teachers of both branches should be informed about science-mathematics integration and integrate them into their lessons.

Keywords: integration, science-mathematics integration, teacher education

Ortaokul Fen ve Matematik Öğretmenlerinin Fen-Matematik Entegrasyonu ile İlgili Görüşleri

Özet (Türkçe)

Bu çalışma ortaokul fen ve matematik öğretmenlerinin fen-matematik entegrasyonu hakkındaki görüşlerini belirlemek amacı ile gerçekleştirilmiştir. Nitel araştırma türünde gerçekleştirilen bu çalışmaya toplam 38 öğretmen (19 fen öğretmeni, 19 matematik öğretmeni) katılmıştır. Çalışmaya alınan fen öğretmenlerinin tamamı entegrasyonun gerekli olduğunu düşünürken matematik öğretmenleri farklı görüşler bildirmiştir. Öğretmenlerin diğer branş öğretmeni ile genellikle fikir alışverişinde bulunduğu belirlendi. Matematik öğretmenleri en çok Türkçe dersi ile entegrasyona ihtiyaç duyduğunu belirtirken fen öğretmenleri en çok matematik dersi ile entegrasyona ihtiyaç duyduklarını belirmişlerdir. Öğretmenlere göre entegrasyonun en önemli avantajı öğrenci ders başarısını arttırmasıdır. Bunlara ek olarak öğretmenlerin fen ve matematiğin ortak becerilerini de yeterince bilmediği görülmüştür. Sonuç olarak fen ve matematik öğretmenleri fen-matematik entegrasyonunu duymuş olmalarına rağmen yeterli düzeyde bilgi ve uygulamaya sahip değillerdir. Bundan dolayı her iki branştaki öğretmenlerin fen-matematik entegrasyonu konusunda ve bu entegrasyonu derslerine nasıl entegre edebilecekleri konusunda bilgilendirilmeleri tavsiye edilmektedir.

Anahtar Kelimeler: entegrasyon, fen-matematik entegrasyonu, öğretmen eğitimi

Introduction

Science education is one of the important courses that give students the ability to comprehend the events that take place in life, to make inferences about the event, and to think about possible situations. In this respect, it can be said that science education continues both in school and out-of -school (Koseoglu & Kavak, 2001). Beyond being a single course, science is a course that covers the subjects and basic concepts of physics, chemistry and biology. For this reason, in order to be successful in this course, first of all, a unity between these three courses must be ensured. With the need to combine various branches of science in a single course, as in the three courses mentioned, the concept of integration has also started to become widespread (Gurdal et al., 2001).

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It is seen that the concept of integration, which has become widespread with the increasing number of researches in education, has different definitions in the literature. Turkish Language Institution defines integration as integration and harmony (TDK, 2023). Many terms such as interdisciplinary, mixed, deep, sequential, fused, blended, combined can be used for integration. Among educators, the more common words are “interdisciplinary,” “fused,” and “thematic”. Lederman and Niess (1997) defined fused as the blending of science and mathematics in such a way that different fields cannot be noticed, that is, a mixture of science and mathematics in which a connection can be established between two interdisciplinary subjects but both subjects can be seen separately. The purpose of integration is to learn the determined subject as a meaningful whole (Turna & Bolat, 2015). In order to ensure learning as a whole, the lessons must be well associated with each other. The success of learning also depends on making this association correctly and completely. The relationship between science and mathematics is also a natural interaction rather than coercion. The majority of the subjects in both disciplines have emerged with the interaction or cooperation of these two disciplines. These two disciplines, which are similar to each other, contain similar subjects within themselves (Hurley, 2001). It is very difficult to understand science without understanding the mathematics that provides information about laws, rules and equations (Trowbridge et al., 2004). It would be correct to use the term "two sides of a coin" for science and mathematics, which cannot be separated from each other. Any progress in science is based on a broader understanding of mathematics. This is a strong reason for integration (Al Orime & Ambusaidi, 2011).

It is reported in the literature that science and mathematics courses have a strong interdisciplinary connection (Kıray & Kaptan, 2012; President et al., 2010). Park Rogers and Volkmann (2007) stated in their study that students understand abstract subjects in mathematics with the help of science lesson, and they also learn science lesson in depth through mathematics.

In today's world, where science and technology are advancing rapidly, it is recommended that students be given the chance to associate and structure lessons instead of rote learning (Ministry of National Education [MONE], 2018). It is the teachers who will associate the lessons with each other. No matter how much the necessity of integration is expressed, it will not be possible to implement this practice if the teachers at the application stage do not believe in the necessity of the application. Therefore, the opinions and practices of teachers are very important (Akpınar & Ergin, 2005; Aytaç, 2003; Kahyaoğlu, 2005). It is stated in the literature that teachers do not find integration necessary (Temel, Dundar & Senol, 2015). One reason why teachers do not find integration necessary may be that they do not know what integration is or how it can be applied (Basista & Mathews, 2002). An unknown situation causes anxiety in individuals. As the individual becomes anxious, they may delay or ignore the action. In the study conducted by Bulunuz and Ergül (2001) to determine the self-confidence of pre-service teachers in using mathematical knowledge and laboratory measurement tools in science teaching, it was concluded that teachers did not trust themselves in organizing and evaluating the data obtained (grouping, and drawing graphs). The most important reason for this insecurity is that teachers do not have the necessary mathematical knowledge and experience. If teachers explain what science-mathematics integration is and how it can be applied properly, the benefits mentioned in the sources will be provided (Kıray & Kaptan, 2012).

It is accepted that teachers have important responsibilities in order to ensure integration between courses (Ekici, 2022). For this reason, first of all, teachers should have knowledge and application skills about what integration is, how it is applied, its advantages and disadvantages and benefits. When the literature is examined, few studies on science-mathematics integration have been found (Kıray & Kaptan, 2012, Tekerek, 2022; Temel, Dundar & Senol, 2015). For this reason, this study aims to determine the views of science and mathematics teachers about science-mathematics integration.

Method

The study used case study design, one of the qualitative research designs, in order to achieve the aim of the study. Case study design is one of the effective designs to deeply investigate a phenomenon. In this case, the phenomenon is teachers' opinions on the integration of science-mathematics subjects to take the advantages of integrated instruction.

Participants

The population of this research, which was carried out in the form of qualitative research, consisted of all science and mathematics teachers working in secondary schools in the Tercan District of Erzincan Province located at the Northeast of Türkiye in the 2015-2016 academic years. The easily accessible sampling method was chosen as the sampling method. At the end of the data collection process, a total of 38 teachers, including 19 science teachers and 19 mathematics teachers, were reached.

The average age of the science teachers who participated in the interview is 30.3 years (min=25 years; max= 46 years), the average age of the mathematics teachers is 31.2 years (min=21 years; max=51 years), and the average of science teachers' working years is 6.7 years (min= 1 year; max=23 years), while mathematics teachers have 9 years (min=1 year; max=29 years). While nearly half of the science teachers (57.9%) are female, nearly half of the mathematics teachers (68.4%) are male. More than half of the teachers in both groups stated that they took seminars/courses related to their field. It was observed that the teachers participating in the study had different interests.

Data Collection

The data were collected using a semi-structured interview form developed by the researchers in line with the literature. After the data collection form was created, two experts in the field of STEM education were sent for the validity of the questions, and their opinions about the form were received. In order to examine the clarity of the questions in the interview form, a pilot study was conducted with one-to-one interviews with four teachers (two science and two mathematics teachers) who were not in the study group. And then the questions that were difficult to understand by the teachers were rearranged. After the questions were finalized, the opinions of two different science and two mathematics teachers were taken.

In the data collection form, there are five questions including the questions of getting to know the teachers (age, gender, working year, department from which they graduated, etc.) and 11 questions about the integration of science and mathematics (the way of defining integration, application skills, views on advantages and disadvantages, etc.). It consists of 16 questions in total.

Interview technique was used to collect data. Interviews were carried out in a predetermined time period when the teacher and the researcher were suitable. The interviews with the teachers were carried out in a room where the researcher and the teacher were alone, as quiet as possible and away from external factors. Before starting the data collection process, all interviews were audio-recorded after obtaining permission from the teachers to record the interviews, and each interview lasted approximately 15 minutes.

Data Analysis

Descriptive statistics (number, percentage, mean, standard deviation), descriptive analysis and content analysis were used in the analysis of the data obtained from the interview questions directed to the teachers. The frequency values (number, percentage) of the answers collected in the subgroups determined as a result of the analysis of the voice recordings of the teachers participating in the research were taken and comments on the teachers' opinions were added.

Findings

Table 1. Distribution of teachers by exchanging ideas with mathematics/science teachers while planning lessons (n=38)

Exchange of Ideas	Science teacher		Mathematics teacher	
	n	%	n	%
Not exchanging ideas	4 (S1, S2, S6, S15)	21.1	6 (M1, M2, M11, M15, M16, M19)	31.6
Those who have exchanged ideas	15	88.9	13	68.4
About the subjects she had trouble explaining and her way of teaching	3 (S3, S5, S9)	15.8	3 (M3, M4, M13)	15.8
Whether the subject is handled	7 (S3, S10, S11, S12, S13, S14, S19)	**36.8**	-	-
Topics that students lack/difficulty	4 (S4, S7, S16, S17)	21.1	2 (M5, M6)	10.5
Issues that need to be addressed in terms of science	2 (S5, S8)	10.5	-	-
Curriculum adjustment	1 (S18)	5.3	8 (M7-10, M12, M14, M17, M18)	**42.1**

*Some teachers stated more than one situation.

The fourth theme was the relation of science and mathematics in course materials (book, program). 10 teachers (4 science and 6 mathematics teachers) who participated in the interview think that there is no problem in the course books and curriculum about associating science and mathematics. While the subject that is most inadequate in associating the lessons is the subject of graphics for science teachers, it is all subjects for mathematics teachers. The subject of strength and movement, which is considered insufficient, is the common opinion of the teachers of both branches (Table 2).

Table 2. Distribution of teachers according to the departments they notice/feel that science and mathematics are not well related in textbooks or programs (n=38)

	Science teacher (n=19)		Mathematics teacher (n=19)	
	n	%	n	%
Not know	2 (S12, S19)	10.5	1 (M10)	5.3
No association whatsoever	3 (S1, S4, S6)	15.8	4 (M3, M7, M11, M14)	21.1
Graphics	5 (S5, S10, S15, S16, S17)	26.3	1 (M5)	5.3
Force and Motion	3 (S5, S10, S14)	15.8	3 (M1, M13, M15)	15.8
Conversions of unit expressions in velocity	3 (S3, S8, S11)	15.8	-	-
Ratio and proportion	-	-	2 (M2, M8)	10,5
Pressure	1 (S13)	5.3	-	-
Simple Machines	-	-	1 (M16)	5.3
Heat Transfer	-	-	1 (M12)	5.3
None	4 (S2, S7, S9, S18)	21.1	6 (M4, M6, M9, M17, M18, M19)	31.6

* Some teachers specified more than one subject.

The fifth theme was the lessons that teachers need outside their fields for meaningful learning. When asked about the branches that teachers need for meaningful learning other than their own branches, science and mathematics teachers gave similar answers. Ranking for science teachers; Mathematics (n=17; 89.5%), Turkish (n=13; 68.4%), Social Sciences (n=3; 15.8%), while the ranking for mathematics teachers was Turkish (n=11; 57%, 9), Science (n=10; 52.6%), Social Sciences (n=3; 15.8%).

The sixth theme was the teaching methods and techniques in science-mathematics integration.

While the majority of science teachers (57.9%) suggested the methods of realizing an integrated lesson in a classroom environment, the same subjects were taught consecutively, while mathematics teachers (31.6%) suggested that both teachers enter the classroom at the same time (Table 3).

Table 3. distribution of teachers' opinions about the methods of realizing an integrated lesson in a classroom environment (n=38).

	Science teacher (n=19)		**Mathematics teacher (n=19)**	
	n	**%**	**n**	**%**
Not know	4 (S1, S2, S5, S6**)**	21.1	2 (M6, M19)	10.5
Sharing lecture notes	1 (S3)	5.3	-	**-**
Establishing a joint math-science classroom/ teachers teaching together in the same class at the same time	1 (S19)	5.3	6 (M9, M11-M13, M15, M16)	31.6
Computing environment	1 (S7)	5.3	-	-
The same topics can be covered consecutively	11 (S8-S18)	**57.9**	2 (M1, M14)	10.5
Not possible with this curriculum	1 (S4)	5.3	3 (M2, M4, M5)	15.8
Practical exam-free course for science and math	-	-	1 (M3)	5.3
Demonstrate and apply in the classroom environment/project assignments	-	-	5 (M7, M8, M10, M17, M18)	26.3

The seventh theme was the advantages and disadvantages of science-mathematics integration. When the advantages and disadvantages of science-mathematics integration are evaluated according to teachers' opinions; the vast majority of science teachers (n=14; 73.7%) and mathematics teachers (n=12; 63.2%) stated that integration was not a disadvantage (Table 4).

Table 4. Advantages of integration according to teachers (n=38)

	Science teacher (n=19)		**Mathematics teacher (n=19)**	
	n	**%**	**n**	**%**
Increases student achievement	8 (S3, S5, S6, S8, S11, S13, S14, S19)	42.1	3 (M7, M12, M13)	15.8
Students learn more easily	8 (S1, S2, S7, S9, S10, S12, S16, S17)	42.1	4 (M2, M7, M14, M16)	21.1
Provides meaningful learning	3 (S11, S18, S19)	15.8	9 (M1, M6, M8, M10, M11, M15, M17-M19)	47.4
Provides convenience for the teacher	2 (S15, S16)	10.5	-	-
Not answer the question	1 (S4)	5.3	4 (M3, M4, M5, M9)	21.1

*Some teachers stated more than one advantage.

The eighth theme was the common skill in science and mathematics integration.
All of the teachers who participated in the interview think that science-mathematics integration requires common skills. While the common skill for both courses is numeracy according to science teachers, it is interpretation and inference according to mathematics teachers (Table 5).

Table 5. Common skills of science and mathematics by teachers (n=38)

	Science teacher (n=19)		Mathematics teacher (n=19)	
	n	%	n	%
Problem solving	2 (S4, S18)	10.5	-	-
Reasoning	3 (S6, S12, S19)	15.8	3 (M4, M9, M17)	15.8
Numerical skill	6 (S5, S7, S8, S10, S14, S15)	**31.5**	4 (M8, M13, M14, M19)	21.1
Equation forming	1 (S13)	5.3	-	-
Interpreting and creating results	-	-	5 (M5, M6, M11, M15, M16)	**26.3**
Connection	-	-	2 (M7, M12)	10.5
Not answer the question	7 (S1-S3, S9, S11, S16, S17)	36.9	5 (M1-M3, M10, M18)	26.3

The ninth theme was the effect of affective characteristics on science and mathematics integration. Science and mathematics teachers were asked whether they would create a common interest/attitude towards science and mathematics. All of the teachers who participated in the interview think that the student's interest in both courses should be high. The majority of teachers of both branches (Science n=14; 73.7%; Mathematics n=17; 89.4%) stated that a common interest could be formed.

The ten theme was evaluation of an integrated program When teachers' views on the evaluation of an integrated curriculum are examined; while the first recommendation of science teachers is process-oriented practice-oriented evaluation without an exam (36.9%), the first recommendation of mathematics teachers is to conduct a joint exam for both courses (26.3%) and to hold a separate exam (26.3%). The opinions of two teachers (S3 and M3) who think that course evaluation should be process-oriented and practice-oriented rather than exam are as follows, respectively:

> In experiments in science, if the mathematics teacher, that is, two teachers, could enter together at the same time, he could see that ability of the children. How many measurements can they take? How much numerical data can they act using? There is no such thing as assessment and evaluation to be done in writing. To what extent can he integrate mathematics into daily life or science lessons in concrete situations? How much can he apply in his daily life? These also need to be evaluated. I think it should definitely be done for practice. In other words, things like a written exam or an oral exam can be made, depending on the teacher's request. It can be useful at certain points. But I think a purely application-oriented integrated form would be good.

Conclusion and Discussion

In this study, which was conducted to determine the views of secondary school science and mathematics teachers on science-mathematics integration, almost all of the science and mathematics teachers reported the need for integration. However, teachers think differently about the courses that need to be integrated. While the science teachers stated that they needed integration with the mathematics lesson most for their own lessons, the mathematics teachers stated that the integration with the Turkish lesson would be more appropriate. In addition, some mathematics teachers emphasized that science-mathematics integration is necessary for science lessons. This finding is similar to the literature (Başkan et al., 2010; Kıray et al., 2008; Meisel 2005).

In the study, it was seen that some teachers did not find integration necessary as in the literature. This is a factor that can affect both the definition of integration and the implementation of integration by teachers. In this direction, teachers' definitions of integration were examined and it was seen that 46% of mathematics teachers and 42.9% of science teachers defined integration as integration. It was determined that the teachers' definition of integration focused on three concepts. These are merging, integrating and interconnected courses. There are many definitions of integration in the literature. Integration isn't just about bringing together similar knowledge and skills from various disciplines, nor doing some social, some science or math over the course of a lesson. In its original meaning, integration is the organization of teaching around subjects, concepts or problems and the effective integration of knowledge from different disciplines in their processing (Yıldırım, 1996). When the definitions of integration of the teachers participating in this study are evaluated, it can be said that all definitions are somewhat shallow. The reason why teachers' definitions of integration are slightly different from the literature suggests that their knowledge of integration is not obtained through education, but through hearsay.

In this study, in which the cooperation of teachers with other branch teachers was evaluated, the majority of teachers stated that they exchanged ideas with other branch teachers. Similar results are reported in the literature (Kıray et al. 2008). If an integrated program is to be implemented, it is very important to provide an interdisciplinary exchange of ideas before the implementation, and this exchange of ideas during the curriculum arrangement (Chrysostomou, 2004).

In the study, teachers were asked about the good association of science and mathematics courses in textbooks or programs. About 1 of 4 of the teachers thinks that science and mathematics are well related. On the other hand, other teachers reported that some subjects were not correlated. The subject of force and movement, which is thought to be not related, is the common point of both branch teachers. Bütüner and Uzun (2011) determined that students have mathematics-based problems, especially in the subjects of force and motion, simple machines and speed. The continuation of the problems experienced in the science subjects mentioned in the literature suggests that the regulations regarding the curriculum are insufficient.

In this study, which examines the courses that teachers need most in terms of integration other than their own branches, it was found that the answers given by the teachers for both branches were common and there were differences in the order. While the courses that mathematics teachers most need integration in terms of their branches are Turkish, Science and Social Sciences, respectively, the ranking for science teachers is Mathematics, Turkish and Social Sciences. Teachers of both branches consider the Turkish course necessary in terms of integration. There are also studies in the literature stating that integration with the Turkish course is necessary (Kaya, 2017; Obali, 2009). Güleç and Alkış (2003), on the other hand, determined that the course most associated with mathematics was Science. In the same study, it was reported that the course with the highest average correlation coefficient between Science and Social Studies was the Social Studies course, and the correlation coefficients between Science and Mathematics were also very high. Wang (2005) similarly stated that there is a moderate relationship between science and mathematics. Considering all the findings, it can be said that they are united in the integration of Science-Turkish-Mathematics.

In the study, about the method of realizing an integrated lesson in the classroom environment, the majority of the mathematics teachers were to establish a joint mathematics-science classroom or to teach science and mathematics teachers together in the same class at the same time, while the science teachers recommended the same subjects for both branches to be taught consecutively. Similar results with this study are reported in the literature. Bütüner and Uzun (2011) suggest that science-mathematics subjects should be carried out in the same parallel and cooperation between science-mathematics teachers should be made in order to solve the problems that may arise among the teachers participating in the study.

According to the mathematics teachers in the study, the first place among the advantages of integration was that it provided meaningful learning. This much; It was followed by the fact that students learn more easily and increase the success of students. The order of science teachers about the advantages of integration is; students learn more easily, increase students' success and provide meaningful learning. While there is no mathematics teacher who thinks that integration provides convenience for the teacher, two of the science teachers think so. In the literature, there are studies stating that integration increases student achievement as one of the most important advantages (Hill, 2002; Hurley, 2001; Kaminski et al., 2004; Kaya et al., 2006; Kıray & Kaptan, 2012; Turna & Bolat, 2015).

In the study, half of the science teachers emphasized numerical skills for the common skills of science and mathematics courses, while mathematics teachers emphasized interpretation and deduction and numerical skillsThe skills that science teachers talk about; problem solving, reasoning, numerical skills and data processing and model building, while mathematics teachers mentioned interpretation and inference, numerical skills, reasoning and association skills. In the study of Kıray and Kaptan (2012), it is stated that science and mathematics have common skills and they are grouped under the following headings; association, problem solving, reasoning, comparison-classification, estimation, data processing and model building, interpretation and inference, estimation, inference, measurement, communication, data recording, information and data collection, observation. Accordingly, it is seen that the teachers participating in this study know very little of the above-mentioned common skills.

Science and mathematics teachers were asked whether they would create a common interest/attitude towards science and mathematics. All of the teachers who participated in the interview think that the student's interest in both courses should be high. On the other hand, while the majority of the teachers argued that a common interest could be created for both courses (science=82.4%; mathematics=94.4%), only a few of them stated that they could not. Kıray et al., (2008) stated that all of the science and technology teachers (n=5) and the majority of the mathematics teachers (n=3) consider the knowledge and skills of the other course while determining the assessment and evaluation criteria of the students, and that the success of the students in one course is the success of the other course. They said it also affected them.

When teachers' views on the evaluation of an integrated curriculum are examined; While the first recommendation of science teachers is process-oriented application-oriented evaluation without an exam (43.7%), the first recommendation of mathematics teachers is to conduct a joint exam for both courses (29.4%) and to hold a separate exam (29.4%).) has been. Considering that the process is more important in integration, it is thought that process-oriented assessment will be more useful in student assessment. In the study of Kıray and Kaptan (2012), one of the mathematics teachers was asked to take the process and the other a joint exam before the implementation regarding the evaluation of an integrated curriculum; stated that one of the science teachers emphasized the product and the other teacher emphasized the product and partially the process. As can be understood from both studies, there is no consensus among teachers about the evaluation of an integrated curriculum.

The most accurate way to analyse the success of the integration is to apply the method and detect any problems or glitches. Teachers should be told about the importance of integration and how to implement it. For this reason, it is recommended that information about integration be added to university curricula. In addition, it is recommended to plan studies to determine the effectiveness of Science-Math-Turkish integration expressed by teachers.

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