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MATHEMATICS AND MUSIC RELATIONSHIP: FROM NOTES TO FRACTIONS[1]

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ABSTRACT

This study aimed to enrich the learning environment of the 5th grade students with the interdisciplinary activities designed by connecting mathematics and music. The activities integrated the concepts of music such as note, beat, and measure with the concept of fractions in mathematics to ensure active participation of students and to promote meaningful learning. These activities were implemented for 6 lesson hours with 23 fifth grade students attending a middle school in Turkey. Throughout the teaching process, students were asked to represent note durations with fractions, to create measures with certain requirements, and to solve problems involving addition and subtraction of fractions with like or unlike denominators. The students were able to solve the questions on the activity sheet by combining the knowledge of mathematics and music. This teaching experience indicates that the activities prepared in accordance with the interdisciplinary approach might contribute to students' conceptual learning of fractions.
Keywords: adding fractions, subtracting fractions, music, interdisciplinary education.

MATEMATİK MÜZİK İLİŞKİSİ: NOTALARDAN KESİRLERE

ÖZ

Bu çalışmada ilköğretim 5. sınıf matematik öğretim programında Sayılar ve İşlemler öğrenme alanında yer alan "Kesirlerle Toplama ve Çıkarma İşlemleri" konusunda etkinlikler hazırlanmıştır. Armoni, ritim, gam, nota, ölçü gibi temel müzik bilgilerinden yararlanılarak kazanımlara yönelik hazırlanan etkinliklerle öğrencileri aktif kılan öğrenme ortamı oluşturmak amaçlanmıştır. Bu bağlamda çalışmada matematik ve müzik ilişkisi dikkate alınarak hazırlanan etkinliklerle öğrenme ortamının zenginleştirilmesi, öğrencilerin derse aktif katılımlarının sağlanması, öğrenilenlerin pekiştirilmesi amaçlanmıştır. Bu etkinlikler bir devlet ortaokulunda 5. sınıfta öğrenim gören 23 öğrenci ile 6 ders saati süresince uygulanmıştır. Etkinlik sürecine başlamadan önce 1 ders saatinde de öğrencilere müzik, notalar ve müzik işaretleri hakkında bilgileri hatırlatılmıştır. Süreç boyunca öğrencilerden vuruşlarla nota uzunluklarını oluşturmaları, etkinlikte istenen ölçüleri sağlamaları bunu yaparken de bu bilgileri kesirlerde toplama ve çıkarma işlemlerine yansıtmaları istenmiştir. Öğrenciler matematik ve müzik bilgilerini birleştirerek etkinlik kâğıdındaki soruların çözümlerini gerçekleştirebilmişlerdir. Sonuç olarak, disiplinlerarası yaklaşıma uygun hazırlanan bu etkinliklerin farklı öğrenen öğrencilerin eğitimine katkı sunacağı düşünülmektedir.
Anahtar kelimeler: kesirlerde toplama, kesirlerde çıkarma, müzik, disiplinlerarası eğitim.

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INTRODUCTION

Contemporary education promotes learner-centered classrooms where students take ownership of their learning, inquire about their interests, and build new knowledge through active participation in the learning and teaching process. This view of education is in sharp contrast to traditional teaching which is based on transferring knowledge from the teacher to students through direct instruction. In the modern view of education, students should be encouraged to develop their knowledge and skills through learning activities appropriate to their interests, abilities, and needs (Zhou & Brown, 2017). For this purpose, it is significant to create learning environments enriched with an interdisciplinary approach for students with multiple intelligences.

According to Yıldırım (1996), the main purpose of the interdisciplinary approach is to help students learn the concepts meaningfully through making connections as well as enabling them to improve the knowledge and skills in other disciplines in the process. The interdisciplinary approach helps students combine and integrate knowledge in different fields (Demirel et al., 2008). An interdisciplinary approach is not to relate various disciplines in one lesson, but to build instruction entirely on comprehending a concept or solving a problem by using knowledge from different fields (Yıldırım, 1996). Similarly, Jacobs (1989) defines interdisciplinary instruction as an approach that utilizes more than one discipline to study a concept, topic, or problem.

Although the foundations of the interdisciplinary approach date back to the 1990s, it was emphasized in Turkey's mathematics education with the 2005 primary education mathematics curriculum. With the principle of "Every child can learn mathematics" in the program, a new perspective was brought to mathematics, and mathematics was connected with various disciplines. This study focuses on the relationship between mathematics and music disciplines.

The relationship between mathematics and music dates back to Pythagoras. Pythagoras (580-500 B.C.) realized that the thickness of the sound changes depending on the length of the strings pulled and left, and established the relationship between harmony in music and integers in mathematics (Orhan, 1995). Pythagoras obtained notes of different tones by dividing a 12-piece string into different lengths. Given a string that produces the note C; $\frac{16}{15}$ of it produces the note B, $\frac{6}{5}$ of it produces the note A, $\frac{4}{3}$ of it produces the note G, $\frac{3}{2}$ of it produces the note F, $\frac{8}{5}$ of it produces the note E, and $\frac{16}{9}$ of it produces the note D (Orhan, 1995).

Each piece of music is divided into equal parts called measure or bar. Measures are indicated in numbers in written music and each measure consists of a specific number of beats representing a particular note value (Atli, 2007). While in a simple meter, each beat in a measure is divided into two equal parts, in a compound meter, each beat is divided into thirds. Another aspect of mathematics in music is note values. Note values are durations of notes and indicated by fractions. Only by examining the note values, it can be seen that the basis of music involves rich mathematics (Atli, 2007).

Based on the connections between mathematics and music, researchers have tried to answer such questions as whether there is a relationship between teaching music and mathematics or whether those who has proficiency in music are more successful in mathematics than those who does not, etc. Studies conducted in line with these questions revealed that music education has a positive effect on mathematics achievement (Booth, 2001; Courey et al., 2012; Geoghegan & Mitchelmore, 1996; Haley, 2001; Karşal, 2004; Topçu & Bulut, 2016; Yağışan et al., 2014). Furthermore, Schmidt-Jones (n.d.) suggested that, according to grade levels, certain mathematical and musical concepts could be associated as follows: fraction-rhythm; sets and intersecting sets - clavier and its keys; fractions, ratios, and decimals - frequency and pitch difference; roots and bases - tune equalization. Similarly, the pitch of voice, volume, and rhythm in music correspond to matching and making comparisons in mathematics (Church, 2013). In this study,

activities were designed and applied by associating the concepts of measure and beat in music with the concept of fraction in mathematics.

Ministry of National Education (MoNE) (2009) highlighted the concepts of notes and fractions while mentioning the relationship between mathematics and other disciplines in the primary education mathematics curriculum. The subject of fractions in the spiral mathematics curriculum is included in different grade levels within different standards. The first grade content standards include the concepts of whole and half, and then each year new topics are introduced to students (MoNE, 2018). Implementing an innovative and interdisciplinary method in teaching fractions and operations with fractions, which is one of the most challenging subjects for primary school students, is anticipated to have positive effects on students' attitude towards mathematics, mathematics achievement, and class participation (Altun, 1999). Accordingly, this study aimed to enrich the learning environment with activities designed by considering the relationship between mathematics and music to ensure active participation of students in the lesson and to promote meaningful learning.

ACTIVITY IMPLEMENTATION

The study was carried out with 23 fifth grade students attending at a state school located in the Black Sea Region of Turkey. The necessary ethics committee approval was obtained for the study. The activities shared in the article were designed towards the fifth grade content standards "M.5.1.4.1. Students will be able to understand and perform the addition and subtraction of two fractions whose denominators are equal to each other or whose denominators are multiples of each other." and "M.5.1.4.2. Students will be able solve and construct problems that require addition and subtraction of fractions with equal denominators or denominators that are multiples of each other." The activities were prepared by the first author, who was the responsible teacher for the course at the time of the study, in cooperation with the second author. The implementation process lasted 7 lesson hours; one lesson as a revision of musical terms and the rest 6 lesson hours for implementing the activities. In these activities, concepts such as note and rest values (a whole, half, quarter, etc.,), measure, beat in music theory were discussed. In the preparation process of the activities, music teachers who are experts in their fields were consulted and the activities were revised in line with their opinions.

The first activity aimed to remind the students the names of the notes with beat values such as a whole note, half note, and quarter note. The equivalence relation between notes and the concept of measure of $\frac{4}{4}$ were explained in detail. In addition, the determination of notes with equal beats to a whole note using colored papers; grasping note lengths through clapping and vocalization; creating a rhythm pattern in $\frac{4}{4}$ measure; and the relationship between notes and fractions were emphasized.

In the second and the third activities, there were three main objectives. The first of them was to associate musical notes with fractions, the second was to demonstrate the concept of equivalance between the lengths of musical notes using fractions, and finally, the third was to relate adding and subtracting fractions to the measures and total duration of the notes. Each activity is detailed in the following sections.

Activity 1

One of the aims of the first activity is to remind the students of the music notations and terms they learned in the fourth grade music lesson. At this stage of the lesson, video sources such as Haboğlu (2019) and KhanAcademyTurkce (2014) can be used to support the instruction.

After reminding the students of the music notations and concepts, their relationship with fractions was clarified. Accordingly, the staff, bar lines, and measures were introduced to students. *The staff* is defined as "a set of straight, horizontal, parallel lines drawn on top of each other, consisting of 5 lines and 4 equal spaces." (Akdemir, 2017, p.1044). *Bar line* and *measure* are defined as follows: "The vertical line that divides the total durations of notes and rests into equal time units in a piece of music is called a bar line, and each section is called measure." (Akdemir, 2017, p. 1049).

The students were reminded that "if the measure is 3/4, it consists of 3 quarter notes, whereas it consists of 3 half notes if the measure is 3/2." Afterwards, the students were asked "How many notes are there in 4/4 measure?" The reply was "4 quarter notes." Subsequently, previously prepared colored papers representing the note values were distributed to the students in order to associate the beat with the duration of notes (Figure 1).

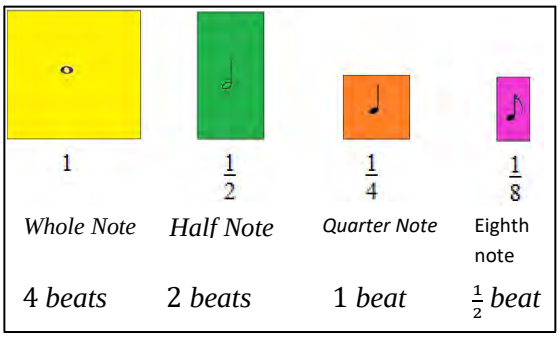


Figure 1. The Beats and Durations of Notes

The students clapped four times by counting one-two-three-four for the whole note, twice by counting one-two for the half note, and once for the quarter note. When students were asked how to perform the eighth note, the answer was a half clap. In other words, if the time until they closed and opened their hands was a beat, that only closing or opening time was the length of the eighth note. They were asked to equalize the number of beats. The response of a student, coded as S_1, to the question "How many half notes were equal to four quarter notes?" was as follows:

> The length of four quarter notes is equal to the length of one whole note. Two half notes are equal to one whole note, as well. Therefore, we can have the length of four quarter notes by using two half notes.

The teacher asked "How can I form a whole note by using the other durations of notes?" Some of the students' replies were as follows:

S_2: Four quarter notes, teacher.
S_3: Two half notes.
S_4: Eight of eighth notes.

Some of the students were able to perform beats by clapping to physically demonstrate the durations of the notes. Besides, they were able to represent the relationship between the note durations with colored papers. A visual showing this situation is presented in Photograph 1.

Photograph 1. From Mathematics and Music Activities

Students were informed about the rests and their symbols which had equal durations with other notes. Figure 2 shows the shapes of notes and rests, their beat times, and names.

Note symbols	Rest symbols	Beat number	Rhytmic name
		4 beats	Whole note
		2 beats	Half note
		1 beat	Quarter note
		½ beat	Eighth note
		¼ beat	Sixteenth note

Figure 2. The Symbols and Durations of Notes

The teacher reminded that the measure of 4/4 had four-quarter notes. The 4/4 measure sample given in Figure 3 was examined in the classroom. The students concluded that the sum of four eighth notes and two quarter notes is equal to the measure of $\frac{4}{4}$, and similarly the sum of one quarter note and six eighth notes constitutes $\frac{4}{4}$ measure.

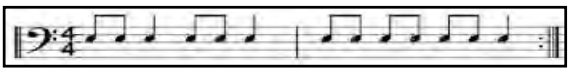


Figure 3. An Example of a $\frac{4}{4}$ Measure

The students were asked to find other examples suitable for this measure by using notes with at least two different lengths of time, write the examples on paper, and perform them by clapping their hands. Figure 4 shows one of the student responses.

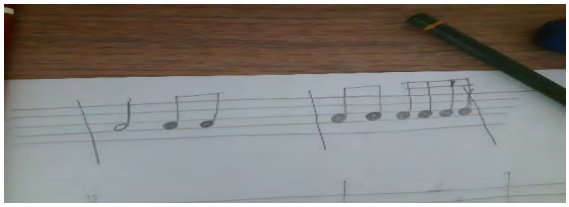


Figure 4. Measure Created by a Student

Most of the students correctly created the required measure. At the end of the activity, worksheet 1 given in Appendix 1 was distributed to the students. It was observed that the students learned the symbols of the notes, their duration, and the concept of measure, and that they could correctly write measures using the relationship between the duration of notes.

Activity 2

This activity targets the content standard "M.5.1.4.1. Students will be able to understand and perform the addition and subtraction of two fractions whose denominators are equal to each other or whose denominators are multiples of each other." and aims to promote students' reasoning skills as well as making connections between mathematics and music. In this 3-hour-activity, students were asked to add and subtract the notes having the same duration values. At this stage, worksheet 2 given in Attachment 2 was used. They were able to add and subtract the note durations having the same values without any transformation. However, they used the rhythmic value chart given in Figure 5 to add or subtract fractions representing notes with different durations by making the denominators equal to each other.

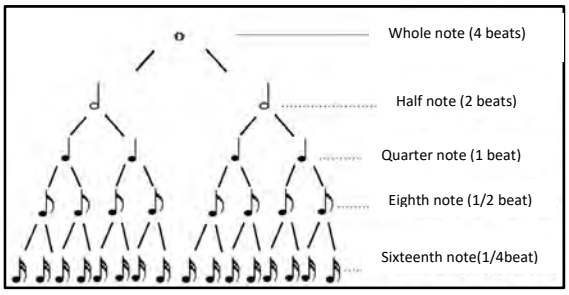


Figure 5. Rhythmic Value Chart

The students were able find how many notes smaller in duration there were in a note longer in duration and they were able to perform addition and subtraction of fractions with the help of the rhythmic value chart. For instance, while adding or subtracting a half note and a quarter note, they transformed the half note into two quarter notes. Thus, they obtained a common denominator in order to add fractions with unlike denominators. When adding a fraction with a natural number or subtracting a fraction from a natural number, the whole note was used instead of the natural number. A visual from the activity process is presented in Photograph 2.

Photograph 2. A Student Answering Worksheet 2

While adding two fractions with like denominators; for example, $\frac{3}{4}+\frac{2}{4}$, it was discussed that $\frac{3}{4}$ contained three quarter notes and $\frac{2}{4}$ contained two quarter notes. Therefore, the operation $\frac{3}{4}+\frac{2}{4}$ means adding 3 quarters and 2 quarters, resulting in 5 quarters. These operations were linked with the note symbols and durations (Figure 6). Students demonstrated the addition by clapping hands.

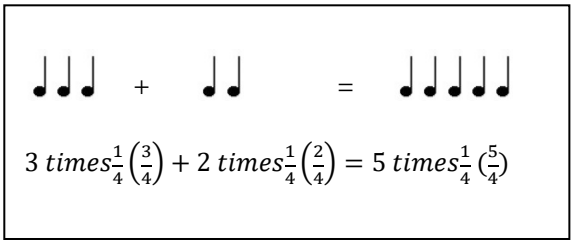


Figure 6. Using Notes in Addition of Fractions

An example dialogue between the students and the teacher from this stage of the lesson is as follows:

Teacher: What is the sum of one quarter note and another quarter note?

S_1: It is two quarter notes.

Teacher: Can you tell us the two quarter notes as a fraction?

S_2: 2/4

Teacher: What is the total duration of one eighth note and two eighth notes? Who wants to explain it using the fractions?

S_3: It is three eighth notes, the fraction is 3/8, teacher.

One of the students explained that "In order to add the notes with the same duration, for example, adding a quarter note and a quarter note makes two quarter note durations, in fractions adding ¼ and ¼ makes 2/4, we simply add the numerators." Similar feedbacks came from the other students. As a result of the activity, it was concluded that "To add the fractions with like denominators, the sum of the numerators are written over the common denominator."

To subtract two fractions with like denominators, the steps in the addition process are repeated with subtracting instead of adding. Figure 7 illustrates a subtraction operation.

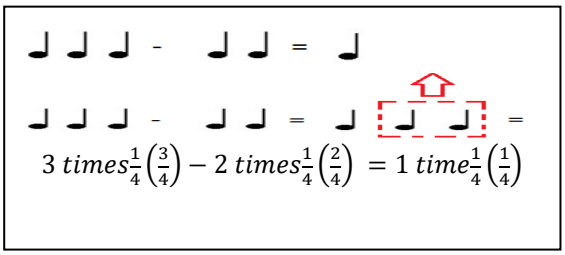


Figure 7. Using Notes in Subtracting Fractions

In order to add fractions with unlike denominators, the duration of notes is converted to equivalent note durations. For example; in $\frac{1}{2}+\frac{1}{4}$, the fraction with the smaller denominator (2) has a larger note length, and it can be converted into sum of shorter notes to have a common denominator. In this example, a half note has two beats, while a quarter note has one beat. Since a half note is equal to two quarters, a half note can be converted into two quarter notes ($\frac{1}{2}=\frac{2}{4}$). After getting the common denominator, simply add the numerators. One of the students used the rhythmic value chart as fraction sets to perform the operations. By using the equivalence between the lengths of the notes, the denominators of the fractions are equalized and the result of the operation is obtained. A sample dialogue with students during the processes is as follows:

Teacher: We will add the duration of a half note and a quarter note, what should we do for this?

S_4: The number of beats in their duration is important.

S_5: The quarter note has one beat, while the half note has two beats.

Teacher: Can we use our rhythmic value chart?

S_6: Yes, teacher. The duration of one unfilled head with stem [the student means half note] corresponds to the duration of two filled heads with stems [he means a quarter note]. We can use two filled head with stems instead of one unfilled head with stem.

S_7: Teacher, my friend wants to express that one half note is equivalent to two quarter notes. To say it with fractions, $\frac{1}{2}=\frac{2}{4}$. Here, we can add two quarters and one quarter and get three quarters. So the answer is $\frac{3}{4}$.

At the end of this dialogue, the operations shown in Figure 8 were written on the board.

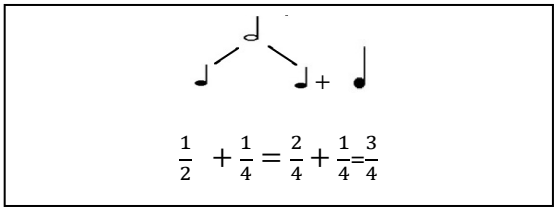


Figure 8. Adding Fractions with Unlike Denominators

In order to add a whole number and a fraction, a whole note was used instead of a whole number. For example, the number 3 was expressed with three whole notes. The operation $2+\frac{1}{4}$ is shown in Figure 9. The students calculated that two whole notes are equivalent to eight quarter notes ($2=\frac{8}{4}$). Afterwards, they followed the same steps of adding like fractions.

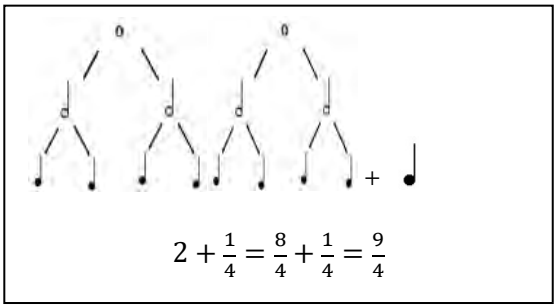


Figure 9. Adding Fractions with a Whole Number

To subtract two fractions with unlike denominators, the notes were converted into notes with equal durations. To illustrate, the

steps for $\frac{5}{8}-\frac{1}{2}$ are shown in Figure 10. The analysis of the subtraction $2-1\frac{1}{4}$, given as an example of subtracting a fraction from a whole number, is shown in Figure 11.

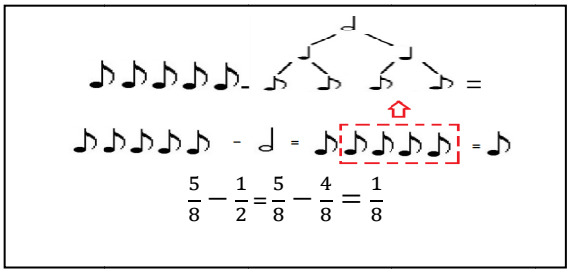


Figure 10. Subtracting Fractions with Unlike Denominators

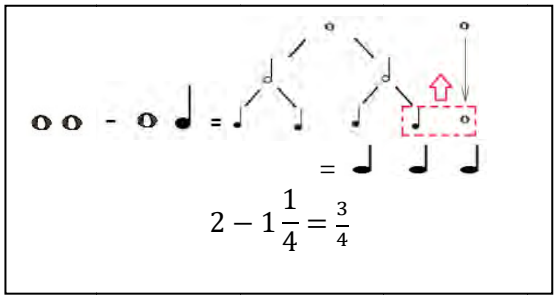


Figure 11. Subtracting a Fraction from a Whole Number

As a result of engaging in this activity, the students concluded that when adding and subtracting fractions with like denominators, they should simply add the numerators and then write the sum over the common denominator. If the denominators were unlike, then they obtained common denominators using the relationships between the note durations.

Activity 3

The activity took 3 lesson hours and focused on the content standard "M.5.1.4.2. Students will be able solve and construct problems that require addition and subtraction of fractions with equal denominators or denominators that are multiples of each other." The aim of this activity is to provide students with such skills as problem solving, communication, reasoning and connecting through solving problems related to music. In this activity, the students were given the measure of a music composition and the duration of some of the notes in the composition. The teacher introduced the activity by saying "Each piece of music has a measure which is a segment of time defined by a specific number of beats." They, they were asked to find the missing note value in the following problem.

Problem: *A composition has a measure of* $\frac{4}{4}$. *There is a quarter note and a half note in one measure. Find the missing note.*

First, steps were planned for the solution. Reasoning strategy might lead us to find the solution. A solution method is adding the note values given, and then, subtracting the sum of note values from the measure of $\frac{4}{4}$. Next, the plan was implemented. For this, the following operations were performed:

The measure of $\frac{4}{4}$ equals four quarters.

$$\frac{1}{2}+\frac{1}{4}=\frac{2}{4}+\frac{1}{4}=\frac{3}{4}$$

$$\frac{4}{4}-\frac{3}{4}=\frac{1}{4}$$

The missing duration is a quarter (♩).

At the final step, the solution was checked. It was checked whether the measure of $\frac{4}{4}$ was obtained by adding the quarter note and half note given in the problem and the resulting quarter note. The result was verified as follows:

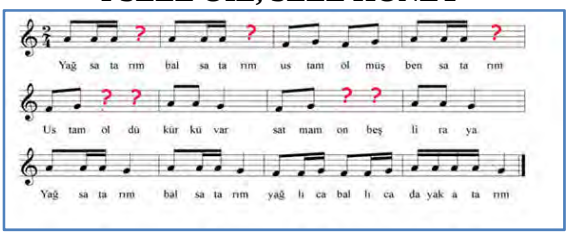
$$\frac{1}{4}+\frac{1}{2}+\frac{1}{4}=\frac{4}{4}.$$

The activity went on with another problem. The teacher asked students that "Ayse first sings a measure of the rhythm of an anthem at a $2/4$ tempo, then a measure of slowrock rhythm at a $6/8$ tempo. How much did Ayse exceed a measure of $4/4$ tempo?" One of the answers from the students (S_8) to this question is as follows: "We should add 2/4 and 6/8 because both of the measures are used. Then, we have to subtract the 4/4 tempo from the result we found so that we can find out how much she exceeded." Another example of the problems solved in the lesson is given in Figure 12. A visual from activity 3 is given in Photograph 3.

The students answered questions and solved problems that require addition and subtraction of fractions in the three activities shared. They were asked questions about the fractional concepts in the process and were guided to

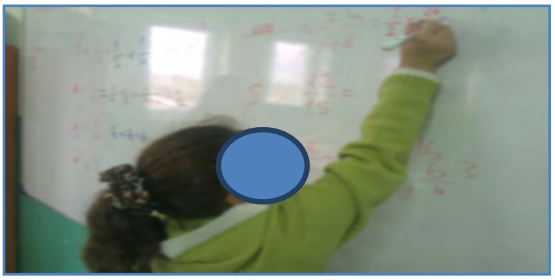
discover rules for adding and subtracting the fractions themselves. The classroom discussion allowed students to share their ideas and give feedback to each other.

I SELL OIL, SELL HONEY



The notes for the song "I sell oil, sell honey" are given above. Can you find the notes in the question mark that the composer deleted by mistake?

Figure 12. One of the Problems Addressed to Students



Photograph 3. A Photograph Representing Students' Participation in the Activity 3

CONCLUSION and SUGGESTIONS

A curriculum design process usually involves integrating the discipline with other fields within the framework of values, skills, and competencies (MoNE, 2018). This study, which was carried out with 23 students attending the fifth grade, consists of activities that integrate the concepts of music such as note, beat, and measure with the concept of fractions in mathematics. The activities were implemented with an interdisciplinary approach. It was observed that the students' motivation was high to participate in the lessons. They played an active role both mentally and physically in the process of forming and operating with fractions using their knowledge of notes. The fact that the necessary preliminary information was given in the beginning prevented any significant problems in the process. Through the questions directed to the students in the activities, the students were supported to construct knowledge about fraction operations, this knowledge was discussed in the classroom, and consequently, common decisions were made on the concepts and generalizations.

At the end of the activities, it was observed that the students progressed positively in understanding operations with fractions and solving problems requiring these operations. This finding is consistent with the findings of previous studies (Courey et al., 2012; Jones & Pearson, 2013) examining the relationship between mathematics and music.

In the activities aimed at adding/subtracting fractions with like denominators, the students were able to perform operations related to the values of notes with the same length of time. In the tasks where notes of different duration were modeled, they were able to find out how many notes with a lower value should be formed by using the rhythm value chart. Therefore, the students realized that when adding or subtracting fractions with unlike denominators, they need to get a common denominator.

In the activity designed for solving problems requiring addition and subtraction of fractions, it was observed that the students could find the missing note values in the music pieces. The three activities shared in this paper seemed to help students comprehend adding and subtracting fractions meaningfully and support their problem solving skills. The connections to music helped to make the activities interesting and meaningful.

Future studies may examine how the interdisciplinary lessons based on the relationship between mathematics and music influence students' performance, motivation, and attitudes towards mathematics. Similar activities can be designed by using different music and mathematics concepts. For example, the topic "operations with fractions" in the sixth grade and the topics "operations with rational numbers" and "ratio-proportion" in the seventh grade can be related to the concept of notes.

Notes

1- Researchers' contribution to the study is equal.
2- This study has been produced from the master's thesis completed by the first author under the supervision of the second author.
3- There is no conflict of interest between the authors.
4- Ethics committee approval was obtained from the institution of the second author, dated 05.29.2020 and numbered 2020/308.

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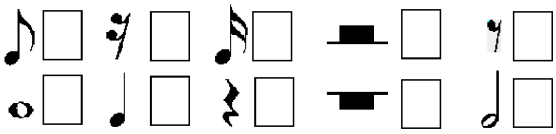
Appendix 1

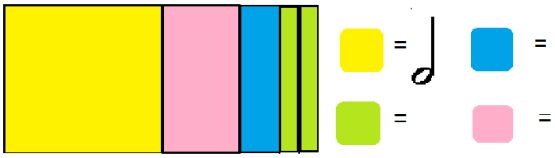
Worksheet 1

1) Use fractions to represent each note and rest.

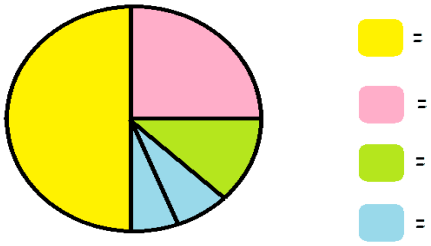


2) Find out which note matches with which color in the shapes given below.

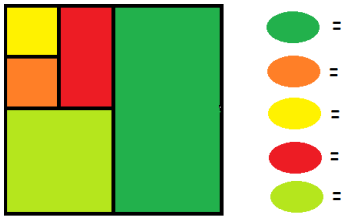
a)



b)



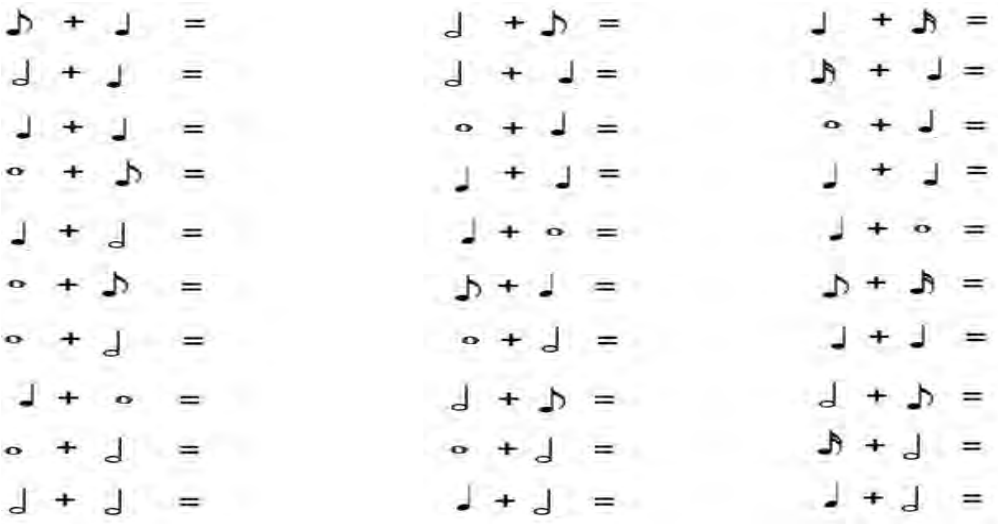
c)



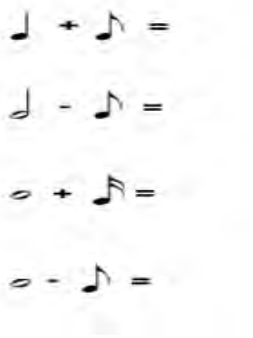
Appendix 2

Worksheet 2

1) Write the length of notes given below and calculate the total duration of notes.



2) Write the length of notes given below and calculate the duration of notes.



3) Fill in the boxes below.