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GAME-BASED ACTIVITIES RELATED TO LIGHT AND SOUND UNIT AND STUDENTS' VIEWS[1]

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ABSTRACT

Game-based learning in science education is an effective method to enhance students' motivation, active participation, and conceptual understanding of the scientific knowledge. This study aimed to encourage teachers to develop and use game-based activities related to the concepts of light and sound and to present students' views about the games developed in the study. The game-based activities were implemented in the 2016-2017 academic year with 27 sixth-grade students. The study reports on the design and implementation processes of 6 games about the light and sound unit. The students evaluated the games by answering 6 open-ended questions. Students' responses were analyzed using the content analysis method, and the findings are shared. The findings showed that the game-based activities facilitated students' learning and created an enjoyable learning environment. Time management is an aspect that should be paid attention to during the games. Teachers are recommended to include games in their lessons.
Keywords: game-based learning, game-based activities, light and sound unit, science education.

IŞIK VE SES ÜNİTESİ İÇİN OYUN TEMELLİ ETKİNLİKLER VE ÖĞRENCİ GÖRÜŞLERİ[1]

ÖZ

Fen eğitiminde oyun temelli öğrenme, öğrencileri hedeflenen öğretim amaçlarına ulaştırmak ve bilimsel bilgiyi öğrenmelerini desteklemek için etkili bir yöntemdir. Bu araştırmada, öğretmenleri sınıf uygulamalarında ışık ve ses ünitesi kavramlarına yönelik oyun temelli etkinlikleri geliştirmeye ve kullanmaya teşvik etmek ve çalışmada geliştirilen oyunlar hakkında öğrenci görüşlerini paylaşmak amaçlanmıştır. Uygulama 2016-2017 öğretim yılında 27 altıncı sınıf öğrencisi katılımıyla gerçekleştirilmiştir. Çalışmada, 6 tane oyunun hazırlanma ve uygulama süreçlerine ait açıklamalara yer verilmiştir. Ayrıca, etkinliklerin değerlendirilmesi için öğrencilere yöneltilen 6 açık uçlu sorunun içerik analizi yöntemiyle incelenmesi sonucu elde edilen bulgular paylaşılmıştır. Araştırma sonuçları oyun temelli etkinliklerin öğrencilerin öğrenmelerini kolaylaştırdığını ve keyifli bir öğrenme ortamı yarattığını göstermiştir. Zaman yönetimi, oyunlar sırasında dikkat edilmesi gereken bir husustur. Öğretmenlerin derslerine oyunları dahil etmeleri önerilmektedir.
Anahtar kelimeler: oyun temelli öğrenme, oyun temelli etkinlikler, ışık ve ses ünitesi, fen eğitimi.

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INTRODUCTION

The game-based learning refers to learning environments that include playing games to improve students' knowledge and skills in an engaging way (Wang & Zheng, 2020). The game-based learning in science education is an effective method to help students achieve the learning goals and support their learning of scientific knowledge (Li & Tsai, 2013; Wang & Zheng, 2020). There are two types of game-based learning, digital and non-digital games. Digital games are played using electronic devices such as computers, mobile phones, tablets, and online applications (Hartt et al., 2020). Non-digital games refer to games that use any board, card, or other types of games that can be played in physical environments (Uzun et al., 2013). Naik (2014) stated that researchers mostly focused on digital games and non-digital games attracted less attention. This study focused on non-digital games and examined how they were used in middle school science lessons.

Previous research studies have reported positive contributions of the game-based teaching to students' learning such as increasing their motivation to participate in the lessons and making the learning environment more enjoyable (Hartt et al., 2020; Kaya & Elgün, 2015; Li & Tsai, 2013; Whang & Zheng, 2020 Yazıcıoğlu & Çavuş Güngören, 2019); supporting long-term learning by making connections between the new and prior knowledge (Aslan, 2014); developing problem-solving skills and feeling of trust and success (Tüzün, 2006); developing a sense of trust through successfully fulfilling the given responsibilities (Pehlivan, 2012); developing self-efficacy (Whang & Zheng, 2020); increasing social interactions (Çatak, 2011); developing positive attitudes towards science (Yazıcıoğlu & Çavuş Güngören, 2019); promoting open-ended thinking (Coşkun et al., 2012), and helping students complete the tasks more carefully with the increasing competition atmosphere (Şahin, 2015). Kaya and Elgün (2015) suggested that the teaching process is carried out more efficiently with games. Games engage the students in active learning and make the lessons more fun (Hartt et al., 2020; Nordby et al., 2016; Yazıcıoğlu & Çavuş Güngören, 2019). Considering all these positive effects, game-based activities should be used more in the teaching and learning processes (Baştürk, 2005; Wang & Zheng, 2020).

Researchers should make further efforts to adapt game designs to learning principles and rigorously evaluate the effectiveness of these designs to establish a stronger relationship between learning and games (Li & Tsai, 2013). The use of games in the science lessons makes the intangible science concepts more tangible and comprehensible for the students (Bayat et al., 2014). The unit of "Light and Sound" includes some concepts that students have learning difficulties (Bakırcı et al., 2015). Yanar et al. (2019) found that some middle school students had misconceptions related to the concepts in the Light and Sound unit, and most of the students had difficulties in defining and describing the light and the related concepts such as propagation, reflection, and refraction. Yüzbaşıoğlu and Kurnaz (2020) pointed out that previous studies generally focused on identifying students' misconceptions about the concept of sound and that there were not enough studies to facilitate learning. Genç et al. (2012) argued that games are crucial to give feedback to both teachers and students about the learned concepts. The current study introduces game-based activity examples that were developed within the scope of a quasi-experimental research on the Light and Sound unit. The study aims to share students' views about the developed games with the readers and to encourage teachers to develop and use game-based activities that facilitate the teaching of light and sound concepts.

ACTIVITY IMPLEMENTATION

The research was carried out in a city in the Eastern Black Sea region of Turkey in the 2016-2017 academic year, and 27 sixth grade students participated in the study. The participants' school was selected by the typical case sampling method (a sampling method that includes non-extraordinary people with average knowledge about the researcher's subject (Canbazoğlu Bilici, 2019, p.69)) because this school was in the city center and the students' average achievement scores were close to each other. Before the implementation, necessary permissions were obtained from the provincial directorate of national education, and publication ethics was followed during the research process. The games were applied by

first author who worked as a teacher in a private education institution. In this process, the official science teacher at the school also helped to manage the classroom, to give the materials to the students, and to make sure that the students followed the game rules. The implementation was completed in 4 weeks in total. The students had 4 lesson hours (40 minutes) for science each week; two of these lessons were spent on playing the games.

The games were developed by a science teacher (the first author) and a science education expert (the second author). After the game-based lessons were planned, they were reviewed and evaluated by another science education expert in terms of applicability and content-curriculum standards relationship. The games were planned to teach the following standards of the Ministry of National Education (MoNE) 2013 elementary science curriculum: *6.4.1.1. Observes the reflections of light on smooth and rough surfaces and represents them by drawing rays. 6.4.1.2. Explains the relationship between the incident ray in the reflection of light, the reflected ray, and the normal of the surface. 6.4.2.1. Understands the situations that may occur as a result of the interaction of sound with the matter. 6.4.2.2. Makes predictions to prevent the propagation of sound and tests the predictions. 6.4.2.3. Explains the importance of sound insulation and gives examples of technological and architectural applications developed for sound insulation* (p. 25).

In the preparation process of the game activities, some criteria were taken into consideration such as compatibility with the content of the course, traditional games that the students are familiar with, and the use of simple and inexpensive materials. In addition to these criteria, the following characteristics of games described by Prensky (2001, p.119) guided the game design process: *rules* (sets limits), *goals and objectives* (motivates), *outcomes and feedback* (informs about the progress), *challenge* (excites to play the game), *interaction* (socializes), and *representation or story* (contains any narrative or story element in the game. For example, chess is a conflict between the players). In order to promote an interdisciplinary education approach, a variety of subject areas (language arts (Turkish), mathematics, arts, music, physical education) were integrated into the games. This approach to game design ensured that the games were compatible with the aspect of the MoNE 2018 science curriculum that emphasizes interdisciplinary connections.

The Pilot Implementation

A pilot implementation was carried out for the researchers to gain experience and to identify the weaknesses of the games. Twenty students participated in the pilot. First, the students were informed about how to play the games, and then they were asked to play the games according to the game rules. In this process, the parts of the games that did not work as planned were identified. Then, the games were revised to address the identified weaknesses. For instance, in the *Search and Find* game, the players had 1 minute to answer the questions. However, the students could not complete the task assigned to them during this time period. For this reason, the time period was increased to 2 minutes. When the game was played again, the students did not have any problems related to time. While playing the *Learning Stations* game, students were given 1 minute to complete the tasks. During this period, the students could not complete the tasks, and the activities were left unfinished. To solve this problem, the time limit to complete the tasks was increased to 2 minutes.

The Main Implementation

The games were played as part of the regular instruction on light and sound. At the beginning of the unit, the teacher first engaged the students in observing how the light is reflected on smooth and rough surfaces using the activities suggested by the curriculum. Then, the students played the designed games on the basic concepts of light to reinforce and assess their knowledge about reflection laws. Next, the students were asked to play the games about the sound unit to help them observe the situations that may occur as a result of the interaction of sound with the matter, discuss what can be done to increase sound insulation, and deepen their knowledge about technological applications on soundproofing. Before playing the games, the teacher informed the students about the game rules, the lesson procedures, and time limitations, and answered the students' questions about the games. At the end, she asked students to do exercises related to the games (e.g., darts).

Learning / Teaching Processes

The games were organized so that the students played one game per each lesson. Accordingly, in the first week of the unit, *darts* and *pişti* (Appendix 1) games; in the second week, *tell the time draw the shape* game; in the third week, *think and win* game; and in the fourth week, *learning stations* and *search and find* games were played.

Darts Game

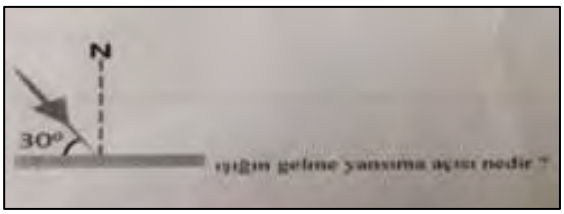
The materials that were used in this game-based activity were magnetic dart and its parts, and the questions sheet about specular and diffuse reflection (Appendix 2). The game is related to the standards 6.4.1.1 and 6.4.1.2.

This game aims to enable students to draw reflections of light on smooth and rough surfaces, and to explain the relationship between incident ray, reflected ray, and surface normal. Additionally, it was aimed for students to reinforce what they have learned in the previous lessons and to relate the lesson topics to real life. This game has connections to physical education with the use of darts. Mathematics was integrated into the game through angle measurement calculations necessary to answer the questions and adding up the points gained during the game.

Darts is a sport that requires being motivated, concentrated, and making decisions in a short amount of time (Cesur, 2019). Therefore, the teacher asked the students to be mentally and physically ready during this activity and to ensure a silent environment to promote concentration during the game. Besides, the students were warned about the security issues before the game started. They were told that the students on the line should stand behind the student who will throw the dart, so that the pointed end of the dart would not harm anyone. No changes were made to the dartboard during the game's preparation process. Questions that require knowledge of and mathematical operations on specular and diffuse reflection, and incident and reflected rays were prepared (Appendix 2). The questions were cut out, folded, and put into a bag. Since two dartboards were brought to the classroom, the students in the class were divided into two groups. Before the game started, the students were asked to line up. The student at the front of the line was asked to throw a dart first, and then pull a question from the bag (Photograph 1).

Photograph 1. Darts Game

The section of the dartboard on which the dart landed on determined the point value of the question. However, to score that number of points, the student had to answer the question correctly. For example, one student was asked to say whether the following statement is true or false: *" While taking head photos, the umbrella behind us causes diffuse reflection of the light."* The student answered the question correctly and the score was written on the scoreboard of his group. The questions about which surfaces have specular or diffuse reflection and whether a statement about the laws of reflection is correct or not were generally answered correctly by the students. Some questions were prepared to reinforce the relationship between the incident ray, the reflected ray, and the normal of the surface, and they required mathematical calculations (Photograph 2). The solution of these questions were written on the board under the guidance of the teacher. Thus, the teacher provided an opportunity for all students to follow the solution steps, to check their own solution methods, and to overcome any learning difficulties.



Photograph 2. A Sample Question

The questions that required calculating angle measures were considered as one of the difficult aspects of the activity for the students (see Table 2). The students who could not answer the questions correctly during the game went to the

back of the line and waited for their turn to throw the dart again. Some students insisted on throwing the dart again due to landing on a section with a low score. The students determined the top three successful throwers in their group. Then, these three students competed among themselves and the group winner was determined. Finally, the group winners competed against each other. The student who gave the most correct answers and scored the most points was announced as the winner of the game. The dart game was the students' favorite game (see Table 1).

Tell the Time Draw the Shape Game

The materials used in this game are as follows: cardboard box, mirror (15x20 cm), clock figures showing various times, different shapes (such as square, triangle) drawn on gridded papers (Appendix 3), and pencil. The game addresses the standards 6.4.1.1 and 6.4.1.2.

The aim of this game is to help students to understand how light is reflected on smooth and rough surfaces and the relationship between light beam and surface normal. Additionally, it was aimed for students to reinforce what they have learned in the previous lessons and to relate the lesson topics to real life. This game integrates art and mathematics with science. It is important to prepare the number of game papers on which the clock and shapes are drawn according to the number of students in the class. Sample clock figures and shapes are given in Appendix 3. Before the activity was played by the students, the teacher demonstrated how to play the game and use the game materials.

The students were divided into seven groups of four members. Each group was given two clock images showing two different times and a paper with a figure/shape on it. While two of the students competed against each other, one of the other two students ensured that the papers were reflected from the mirror in the cardboard box, and the fourth student refereed whether the correct reading and drawing were made or not. The competitor students were first asked to correctly read the mirror image of the clock figure. In this setup, the student only saw the image in the mirror. He/she could not see the projected paper on which there is a clock figure. There were students who were wrong in determining the places of the hour and minute hands while reading the clock. The student who read both hours correctly, was allowed to draw the shape reflected in the mirror (the second part of the game). As in clock readings, the paper was reflected on the mirror and the student was asked to draw the shape on the paper. A challenge was to draw the shape in the given frame based on what is seen from the reflection in the mirror (the student saw his hand only from his reflection in the mirror) (Photograph 3).

Photograph 3. Tell the Time Draw the Shape

Meanwhile, the teacher reminded the students to be careful about the size of the shape, its distance to the mirror, its direction (being in the same direction with the reflected shape), and drawing within the given boundaries because it was observed that the students had a lot of difficulties and made mistakes in drawing the shapes correctly by looking at a mirror. For instance, some students drew the parts of the shape outside the given boundary or drew the direction of the shape incorrectly. In these cases, the group members warned the student to correctly draw the shape. During the drawing phase, the teacher asked the students the following questions to help them make connections to real life: "Why is the word ambulance written in reverse?" "What feature of plane mirrors does this show?" The students explained that the driver in the vehicle in front of the ambulance could read the ambulance text in the rear view mirror quickly and accurately, and this showed the symmetry feature of the plane mirror. Thus, the students realized the importance of symmetry in real life. The experience of drawing the clock and shape figures helped the students better understand the properties of the images formed by plane mirrors. All the students in the group experienced drawing figures. The group winners competed with each other on new

shapes and the class winner was determined.

Think and Win Game

No material is needed for this game. The game was planned to teach the standard 6.4.1.2.

The aim of this game is to enable students to grasp the relationship between the incident ray, the reflected ray, and the normal of the surface by answering questions in a speedy manner. With the question-answer method used in the game, an additional goal is to formatively assess the students' learning. This activity integrates science with music by including various rhythms during the game.

The students formed a circle. The teacher modeled a repetitive rhythm during the game (example rhythm: tap your hands twice on the knees, clap your hands twice, snap your fingers twice. While snapping your fingers, say the concept/example). The rhythm was repeated until all the students learned the rhythm. Then, a student started the game by saying a concept related to light or sound. For example, the first player said "specular reflection." The second player said "shiny marble" as an example of the concept that the first player said. The third player said "diffuse reflection" as a concept, and the fourth player said "rough wall" as an example of diffuse reflection. The game continued in the same manner; one player said a concept, and the next player gave an example of the concept (Photograph 4).

Photograph 4. Think and Win Game

During the game, the sample types were changed on the command of the teacher and the students gave examples according to this type. For example, the teacher said "reflection on the window", and the next player was expected to tell the concept. The students who could not give an answer or gave an incorrect answer were taken out of the game.

Learning Stations

The materials used in this activity are A4 papers as many as the number of groups and colored pencils. The game is related to the standards 6.4.1.1., 6.4.1.2., 6.4.2.1., 6.4.2.2. and 6.4.2.3.

The aim of this activity is to help students make connections between the reflection of light and real life, make predictions about the situations that may occur as a result of the interaction of sound with the matter, and create different products based on what they have learned in the unit so far. Through these processes, the activity provided the teacher with opportunities for formative assessment. Learning stations is a teaching technique in which students move from one station to another to complete various tasks (Karacalı, 2018). The groups of students simultaneously work on different tasks at different stations, but when they move to a new station, they continue the unfinished task left from the previous group. This aspect of the stations activity has the characteristics of being a game. Some researchers included game activities in the stations (Akıllı et al., 2017).

The stations activity of the current study integrated science with literature, art, and music. There were six stations. One A4 paper and colored pencils were given to each station. The tasks to be completed in each station are written on the papers.

Station 1: Briefly explain what you have learned about light.
Station 2: Briefly explain what you have learned about sound.
Station 3: Write a story about the transmission of sound.
Station 4: Write a story about the spread of light.
Station 5: Draw a picture or a caricature about the topics of sound and/or light.
Station 6: Write lyrics about sound and/or light.

All students were divided into six groups. Each group went to a station. The groups were given 2 minutes to work on the tasks. The students were expected to work on the tasks assigned to

them within the specified time (Photograph 5).

Photograph 5. Learning Stations

At the end of the 2-minute time period, the groups moved in the clockwise direction and tried to complete the task left from the previous group. The teacher checked the time and warned the groups to move to the next station at the right time. This process continued until all the groups came to their starting station. Some students tried to continue the task after their time is over. Particularly, the groups at the story writing stations tended to continue the task. The teacher warned the groups about following the instructions. Each group examined the final version of the task that they started and shared the changes made with the other groups.

Search and Find Game

The materials used in this game were the question cards about reflection of light and the interaction of sound with matter (Appendix 4) and a pen. The game was based on the standards 6.4.1.1., 6.4.1.2., 6.4.2.1., 6.4.2.2. and 6.4.2.3.

This game aimed to help students relate the reflection of light to real life, make predictions, and give examples of the situations that may arise as a result of the interaction of sound with the matter. The game also aimed to assess the students' understanding of the topics included in the unit. The game provided the students with opportunities to get to know each other better, make connections to real life, and engage in scientific conversations.

All students in the classroom were asked to come together in front of the board. The students were handed out the papers containing the questions in the table given in Appendix 4. They were asked to find answers to these questions by asking them to their classmates within 2 minutes (Photograph 6). When the time is over, the papers were collected from the students, and the answers were shared.

Photograph 6. Search and Find Game

During the game, the students talked loudly and moved quickly while asking questions to each other. This caused some noise in the classroom. Some students answered the questions themselves instead of asking the questions to their classmates. When the teacher noticed such cases, the students were reminded of the game rules. At the end of the game, the students shared the answers that they got from their classmates. The student who responded to that question confirmed whether the answer was correct or not. An example dialogue from the lesson is as follows (pseudonym names are used):

> Ali: My friend Ahmet sings in the bathroom; the acoustics of the bathroom is high.
> Ahmet: Miss, Ali wrote my answer without asking me, but his answer is correct. Sometimes, I sing in the bathroom and even though my voice is not nice, it sounds like an echo.

EVALUATION of the GAMES

Two teachers observed the students' engagement in the tasks and their learning process during the implementation of the games. The games were implemented as planned. In addition to the teachers' observations, the students' opinions about the game were sought. For this purpose, they were asked to complete a form in the first lesson after all the games were played. This form includes six open-ended questions (Appendix 5). The form was prepared by the researchers, and the opinions of a science teacher and a science education specialist were taken regarding the

questions. The content analysis method was used in the analysis of the students' responses to the questions in the form. Content analysis involves searching for and identification of codes and themes (Patton, 2015, p.790). This analysis method generally focuses on the consistency of qualitative data and the meanings of the data (Patton, 2015, p.790). In the analysis of the data, answers to each question was independently coded by each researcher. Similar codes were put together to form the themes. Regarding the validity and reliability of the study (Yıldırım & Şimşek, 2016: p.277), the following procedures were followed. To ensure the credibility of the study, the data was reviewed multiple times during the analysis process, and direct quotations were shared in presenting the findings. For transferability, data was analyzed using codes and themes, and thick descriptions were used to reflect the participants' experiences. To ensure consistency, after independent coding, the researchers came together to compare their codes and themes, and they reached a consensus on the final codes and themes.

The first question asked students what they liked about the game-based activities that they engaged in the last unit. The students answered this question by sharing their favorite games. The findings are presented in Table 1.

Table 1. Favorite Games

Theme	Code	f	%
Games	Darts	11	38
	Card (pişti)	10	34
	Think and win	8	28
Total		29	100

Table 1 shows that the students liked to play the dart game (38%) the most, then the pişti (34%), and then the think and win game (28%). Sample student answers are as follows.

> S1: Darts, card game *[pişti]*, diffuse and specular reflection game *[think and win]*.
>
> S6: I liked the diffuse and specular reflection *[dart]*, the cards about specular and diffuse reflection *[pişti]*, the specular and diffuse reflection game that we played by forming a U-shape in the classroom *[think and win]*.

The second question asked students about what they disliked and found challenging during the implementation of the games. The findings are presented in Table 2.

Table 2. Students' Views on the Challenging Aspects of the Games

Theme	Code	f	%
Activity type	Identify the type of reflection	4	15
	Angle measurement calculations	2	7
	Solving tests	1	4
Other	No	19	70
	-	1	4
Total		27	100

Table 2 shows that most of the students (70%) did not write any negative aspects about the games. The aspects of the game-based activities that students found challenging included identifying the type of reflection (15%), calculating the angle measurements (7%), and solving test questions (4%). Sample student answers are as follows.

> S3: It was quite difficult to look at the mirror and draw the image correctly without exceeding the border lines *[Tell the time draw the shape game]*.
>
> S9: There is nothing I dislike about the activities you used. I liked and loved all of them.

The third question asked the students what aspects of the game-based activities they found entertaining and educative. Findings on this question are presented in Table 3.

Table 3. Students' Views on the Entertaining and Educative Aspects of the Games

Theme	Code	f	%
Activity type	Specular and diffuse reflection games	14	52
	Sound-related games	8	30
Other	Asking questions	5	18
Total		27	100

According to Table 3, 52% of the students found the games related to specular and diffuse reflection entertaining and educative. The games about the concept of sound were found educative and entertaining by 30% of the students. Some students (18%) wrote that the question-answer method was educative. Sample student answers are as follows.

S2: I found the diffuse reflection and specular reflection game *[think and win game]* entertaining and educative.

S5: For example, while playing darts, everyone picks a question and answers it, which increases our interest and attention towards the science lessons more.

The fourth question asked students which concepts they learned about during the game-based activities. The findings are presented in Table 4.

Table 4. The Concepts Emphasized by the Students

Theme	Code	f	%
Light	Specular and diffuse reflection	15	48
	Light	9	29
Sound	Sound	7	23
Total		31	100

Table 4 shows that the concepts that the students felt that they learned about included specular and diffuse reflection (48%), light (29%), and sound (23%). Sample student answers are as follows.

S7: Sound, light, diffuse reflection, specular reflection.

S4: The activities helped with the concepts of diffuse reflection, specular reflection, light, and sound.

The fifth question asked students what factors helped them complete the tasks during the game-based activities. The findings are presented in Table 5.

Table 5. The Factors that Helped Students Complete the Tasks

Theme	Code	f	%
Cognitive	Learn by doing	13	46
Emotional	Fun	10	36
Psychomotor	Play game	5	18
Total		28	100

According to Table 5, the students explained that they completed the game tasks due to several factors that include learning by doing (46%), fun (36%), and playing games (18%). Sample students answers are as follows.

S11: The games were very fun and educative.

S12: I participated because I understood the concepts better.

Finally, the sixth question asked students' views on the quality of classroom communications during the games. The findings are presented in Table 6.

Table 6. Students' Views on Their Communications with the Classmates

Theme	Code	f	%
Positive	Very good	17	47
	Good	8	22
	Fun	8	22
Negative	Bad	3	8
Total		36	100

Table 6 shows that the students described their communication with the classmates as very good (47%), good (22%), and fun (22%). Some students wrote that their communication was bad (8%) during the games. Sample student answers are as follows.

S13: Good, fun.

S17: We did not have any communication.

CONCLUSIONS and SUGGESTIONS

In this study, six games related to the Light and Sound unit were shared. The games were designed based on the sixth grade science curriculum of the MoNE (2013). The games were used to scaffold students' conceptual understanding of the topics as well as to formatively assess their learning. The findings revealed that the games contributed to students' development in the cognitive, affective, and psychomotor domains. Students expressed the view that they learned the concepts of specular and diffuse reflection, light, and sound. Additionally, the students explained that they enjoyed learning by playing the games and understood the concepts better. According to previous research results, game activities increase student achievement (Yazıcıoğlu & Çavuş Güngören, 2019). Using simulation games to introduce the concept of angle to students, Piu et al. (2016) determined that games facilitate the teaching process in concept introduction. Similar findings were reported in Boyraz and Serin's (2015) research on teaching the concepts of force and motion through physical play activities; the researchers concluded that students learned the science concepts better in a game-based learning environment. In light of the current and previous research results, a recommendation for

teachers is to include more educational games in the science lessons.

Darts, pişti, and think and win games were found to be the most popular games among the students. The most important factors that ensured students' participation in the implementation process were learning by doing and having fun. In addition to these, the students mentioned the educative aspect of the game content as one of the factors that promoted their participation. These factors align with the game characteristics that were taken into consideration during the game design phase of the study. The students' positive comments about the games indicate the effectiveness of the game-based learning approach. Nordby et al. (2016) concluded that games allow students to learn by doing and having fun compared to traditional teaching methods. Slussareff and Boháčková (2016) determined that students who were active in the learning process with educational games performed better than the passive students did. The results of the current research are in line with the results of the related literature.

A great majority of the students stated that their communication with their friends during the process was very good. It was determined that the students actively participated in the games, did not feel competitive during the games, and found the lessons enjoyable. Similarly, Karamustafaoğlu and Kaya (2013) determined that games enabled students to participate actively in lessons and increased their interaction with each other.

The 2013 curriculum standards used in this research study are also included in the renewed MEB 2018 science curriculum. However, minor changes have been made regarding the grade levels. For example, the standards related to the concept of light are now included in the fifth unit of the fifth grade, the light propagation / physical events unit, in the 2018 science curriculum. The standards related to the concept of sound are in the fifth unit of the sixth grade, the sound and its properties / physical events unit. Teachers / researchers who will use the games should consider this revision. Although the games related to the concept of light might be appropriate for the development levels of the fifth grade students, the researchers should use the games by first piloting them with a sample group prior to main implementation.

In the current implementation of the games, the teacher explained the game rules at the beginning of each game. In future implementations, these rules might be reminded at certain periods to have a smooth implementation process. For example, teachers should be careful about the use of time. Additionally, the classroom environment should be designed according to the game requirements, and in games that require focus, such as darts, the students waiting in the line should not distract the thrower by making supportive/unsupportive statements. Since it took too much time to write a story, the content of this station can be revised to include writing a slogan or acrostic or preparing a brochure. Some students might speak loudly because of the excitement of the game. This situation causes noise in the classroom. To solve this problem, a new rule can be defined so that the student, who has been warned twice for speaking loudly, will wait one round, and play in the second round.

The game activities developed in this research required physical participation. Future research studies might focus on examining the effects of using digital games or comparing digital and non-digital games in the teaching of the light and sound unit. More research is needed to better understand the effects of game-based learning in science lessons.

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Appendix 1

The Pişti Game

The materials used in this game are colored cardboard, images related to specular and diffuse reflection, and adhesive. The game was related to the standards 6.4.1.1, and 6.4.1.2.

The aim of this game is to match the concepts of specular and diffuse reflection with related images. Pişti is a card game based on counting cards and chance. It is played with 2 or 4 people. In this study, the students played the game in pairs. The game cards are made of cardboard and has the same size with regular playing cards. Images of specular and diffuse reflection are sticked on the game cards (Figure 1).

Figure 1. Pişti Cards

To play the game, first, the students form pairs. One deck of cards is given to each pair. The rules of this game are as follows: The students are seated face to face or side by side without showing the faces of the cards to each other. One of the students undertakes the task of distributing the cards. The student who distributes the cards shuffles the deck and asks the other student (opponent) to divide the deck of cards into two stacks. There is a special rule here. The student who divides the deck into two stacks cannot make a stack with one card only. The student places the top card on the bottom stack on the table with its face up. This card is used to start the game.

The student who distributes the cards gives each player (himself and the opponent) four cards. The players do not show the card faces to each other. After that, in each round, the cards in the players' hands are played first, and then a new set of four cards are distributed to each player. The game continues until all the cards in the deck finish.

The game starts with the student who divided the deck into two stacks placing one of his/her cards on the card that was initially put on the table. The rule for winning cards is that if two consecutive cards have the same type of reflection (specular or diffuse), the student who puts the last card gets all the cards on the table. If no two consecutive cards happen to have the same type of reflection, the student who put the last specular reflection card takes all the cards on the table. In the meantime, it is the students' responsibility to check the type of reflection on the cards correctly. Thus, the game encourages students to discuss about the types of reflections. At the end of the game, the student who collects the most cards wins the game. The game is repeated three times, then the winners of each pair compete against each other and the winner of the whole class is determined. In the current implementation of the game, this game was found to be one of the most popular games that reinforced students' knowledge on specular and diffuse reflections (See Tables 1-3).

Appendix 2

Questions for the Darts Game

A. On which of the surfaces do specular reflection or diffuse reflection occurs?

1. Stature mirror (Full length mirror)
2. Window glass
3.Wrinkled aluminum foil
4. Concrete wall
5. Ditchwater surface
6. Lampshade
7. Uneven water surface
8.Smooth aluminum foil
9. Mirror
10. Surface of a steel pot
11. Carpet
12. A child looking at the full-length mirror
13. A child looking at a shop window
14. A man looking at the window of a sports car.
15. Glass
16. Wet asphalt floor
17. Parquet floor
18. Marble floor
19. Frosted glass
20. Crystal glass
21. Velvet fabric
22. Silk fabric
23. Polished board
24. Metal surface
25. Paper bag

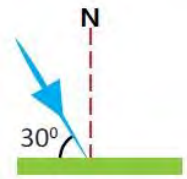
B. Tell whether the statements below are true or not.

1. The angle of incidence is always equal to the angle of reflection.
2. Rays that come to the surfaces of objects are always reflected in the same way.
3. The image formed on smooth surfaces is clearer than the image formed on rough surfaces.
4. Light reflects specular on rough surfaces.
5. The incident ray, the reflected ray, and the normal of the surface are in the same plane.
6. The ray that is perpendicular to the reflective surface reflects back on itself.
7. Rough surfaces are made up of many reflective surfaces.
8. Objects with shiny surfaces may not always cause specular reflection.
9. Light always reflects specular.
10. Light is always diffused when it reflects.
11. While taking head photos, the umbrella behind us causes diffuse reflection of the light.
12. The surface normal is drawn parallel to the surface.
13. When a ray of light approaches a surface and bounces back, this process is called spread of light.
14. Light reflects from reflective surfaces according to the laws of diffusion.
15. Substances are divided into three groups as transparent, translucent, and non-transparent substances according to their behavior against light.

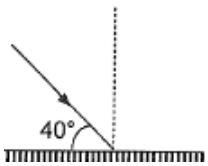
C. Answer the questions.

1. Give two examples of surfaces where light reflects best.
2. Give two examples of surfaces where light is diffused when it reflects.

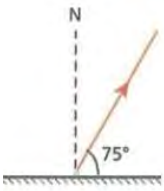
D. Answer the questions on the board.



1. What is the reflection angle of the light?



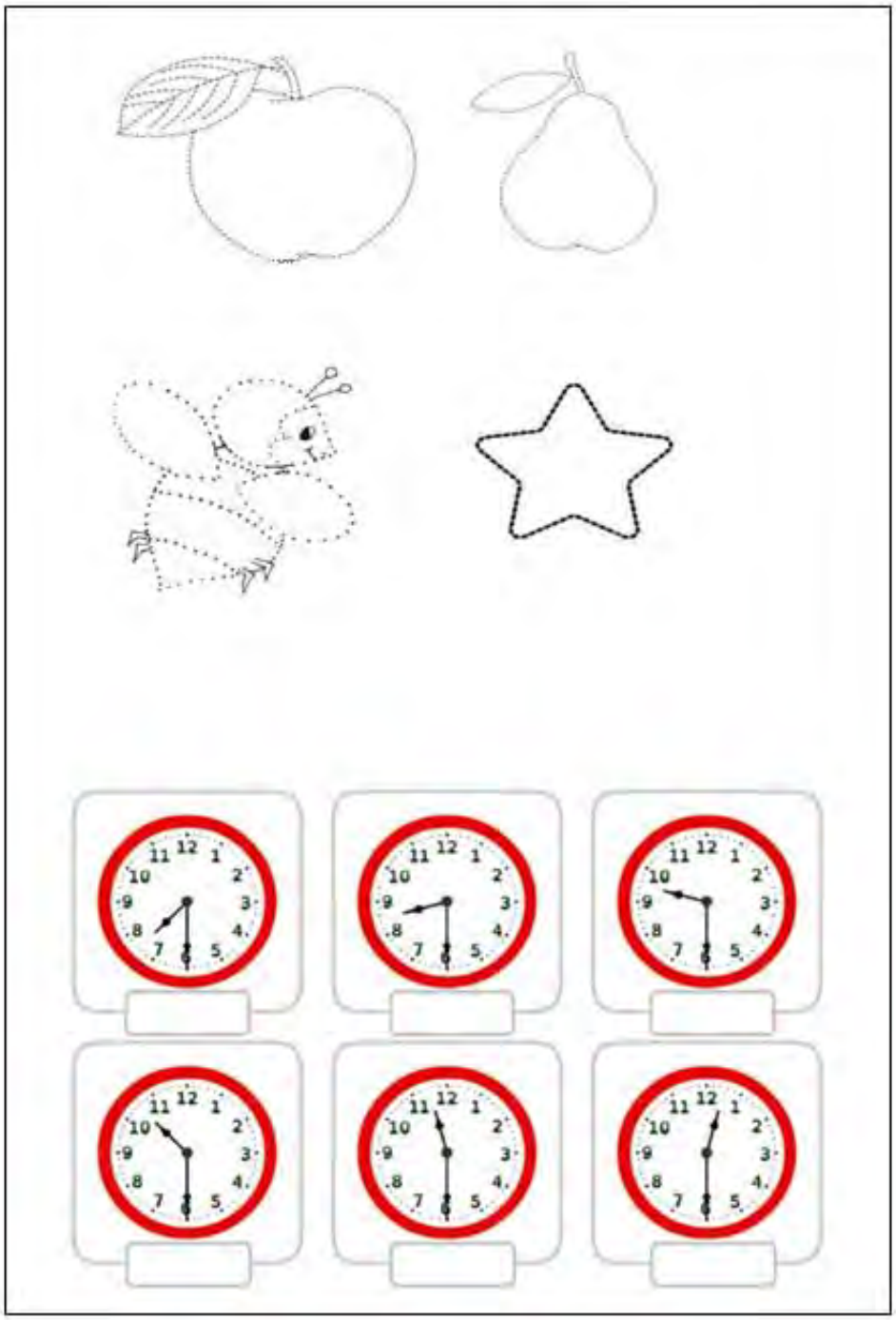
2. What is the sum of incident angle and reflection angle of the ray in the figure?



3. What is the angle of incidence of the light?

Appendix 3

Sample Figures for Tell the Time Draw the Shape Game



Appendix 4

Search and Find Game Question Table

The Features that I am Looking For	**My Notes**
Find a friend who has a crystal chandelier in his/her home and write his/her name.	
Find a friend who has an object with specular reflection in his/her room. Write down the name of your friend and the object.	
Find a friend who has seen a device about the propagation of the sound. Write down your friend's name and the device's name.	
Find a friend who has seen a diffuse reflecting object in your school. Write down the name of your friend and the object.	
Find a friend who has been to the stadium in the past year. Write down your friend's name and how the sound is reflected in the stadium.	
Find a friend who sings in the bathroom. Write down your friend's name and how the sound is reflected.	

Appendix 5

Opinions on the Game-based Activities Used in the Light and Sound Unit Form

1. What did you like about the game-based activities used in the light and sound unit?
2. What aspects of the game-based activities did you not like and find boring or challenging?
3. What aspects of the game-based activities did you find entertaining and educative? Explain your answer by giving examples.
4. Which concepts did you learn by participating in the game-based activities?
5. What factors made you complete the tasks during the game-based activities?
6. What do you think about the quality of your communications with your classmates during the game-based activities?