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TEACHING SOUND INSULATION TO STUDENTS WITH VISUAL IMPAIRMENT WITH THE 5E INSTRUCTIONAL MODEL[1]

Aydın Kızılaslan[2], Cem Aslan[3], Tamer Karakoç[4], Serkan Kapucu[5]

ABSTRACT

Students with visual impairment have the same range of mental abilities as their sighted peers. However, these students experience academic failure, especially in courses in which visual themes are dominant, as they cannot use their sense of sight to process information sufficiently. One of the courses that students with visual impairment have the most difficulty with is science as it contains many visual materials. This study aimed to determine whether students with visual impairment can learn the concept of sound insulation using tactile documents that highlight their haptic senses. The study was implemented in a state secondary school for the visually impaired, and 4 students with visual impairment (blind) participated in the activity. It was observed that all students actively participated during the exercise. The students stated that the practice was fun, instructive, and suitable for teaching the targeted concept.

Keywords: visual impairment, science activity, sound insulation, 5E instructional model.

GÖRME YETERSİZLİĞİ OLAN ÖĞRENCİLERE SES YALITIMININ 5E ÖĞRETİM MODELİYLE ÖĞRETİMİ

ÖZ

Görme yetersizliği olan öğrenciler gören akranlarıyla aynı zihinsel yetenek yelpazesine sahiptirler. Fakat görme yetersizliği olan öğrenciler görme duyusunu yeterince kullanıp bilgiyi işleyemediği için özellikle görsel temaların baskın olduğu derslerde akademik başarısızlık yaşarlar. Görme yetersizliği olan öğrencilerin en çok zorlandığı derslerden biri fen bilimleri dersidir. Çünkü bu ders çok fazla görsel materyal içermektedir. Bu çalışmada görme yetersizliği olan öğrencilerin haptik duyularını öne çıkaran dokunsal dokümanlarla ses yalıtımı kavramını öğrenebilmeleri amaçlanmıştır. Çalışma bir devlet görme engelliler ortaokulunda uygulanmış ve hazırlanan etkinliğe görme yetersizliği olan (kör) 4 öğrenci katılmıştır. Etkinlik boyunca tüm öğrencilerin aktif katılım gösterdiği gözlenmiştir. Genel anlamda öğrenciler etkinliğin eğlenceli, öğretici ve hedeflenen kavramın öğretimine uygun olduğunu ifade etmişlerdir.

Anahtar kelimeler: görme yetersizliği, fen etkinliği, ses yalıtımı, 5E öğretim modeli.

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[2]Assoc. Prof., Ağrı İbrahim Çeçen University, Faculty of Education, Special Education Department, ydnkizilaslan@gmail.com, ORCID: https://orcid.org/0000-0003-3033-9358
[3]Assist Prof., Gazi University, Gazi Faculty of Education, Special Education Department, cemaslan@gazi.edu.tr, ORCID: https://orcid.org/0000-0002-0300-5873
[4]Dr., Gazi University, Gazi Faculty of Education, Special Education Department, tamerk@gazi.edu.tr, ORCID: https://orcid.org/0000-0002-3080-6326
[5]Assoc. Prof., Ağrı İbrahim Çeçen University, Faculty of Education, Department of Mathematics and Science Education, serkankapucu@yahoo.com, ORCID: https://orcid.org/0000-0002-4027-4466

INTRODUCTION

Visual impairment is one of the essential deficiencies that affect an individual's ability to complete daily life activities and reach academic success (Ferrell, 2006). Individuals with visual impairment are defined in two ways, namely as low vision or blind (total visual impairment). Individuals who can use their sense of sight for educational purposes are defined as having *low vision*, and they need adapted tools and a learning environment to maximize their current potential; individuals who require braille (tactile/relief alphabet) or auditory materials are defined as *blind* (Tüfekçioğlu, 2013).

One of the standard characteristics of students with visual impairment is that they have a limited ability to learn by chance from their environment, while sighted students receive most of what they learn through sight (Aslan et al., 2019; Ataman, 2012). In other words, sighted students acquire most of what they learn through visual cues (Ataman, 2003). When it comes to visual impairment, senses other than vision compensate for the deficiencies in the individual's access to information (Şafak, 2007). Therefore, students with visual impairment should learn compensatory skills and techniques to acquire information using methods other than vision. At the same time, teaching methods, techniques, and materials should be developed for the senses other than sight (Bergwerk, 2011). In this sense, it is essential to choose teaching methods, techniques, and materials that maximize students' social interactions, prioritize peer assistance and ensure active student participation (Ferrell, 2006).

Students with visual impairment can achieve academic success at the same rate as their peers in educational environments that consider individual needs (Çakmak et al., 2016). However, it should always be considered that it is often difficult for these students to become fully independent (Yalçın & Aslan, 2021). Therefore, to avoid the "*learned helplessness"* trap, teachers should prepare activities that support students' independent movement skills, emphasize cooperative work, and highlight "tactile" and "haptic" perceptions related to the sense of touch as much as possible (Alnfiai & Sampalli, 2017).

Tactile perception generally refers to feeling the shape, surface, and size of an object (Bara et al., 2018). One object is distinguished from another by its shape, size, material, or color. It may be difficult for individuals with visual impairment and those who use their pure sense of touch to understand objects (Gupta et al., 2017). For this, transferring images to relief requires tactile perception and simplified representation information (Downing & Chen, 2003). *Haptic perception* generally refers to the ability to grasp an object (Davidson et al., 1974). Haptic perception considers an object's size, weight, circumference, material properties, strength, and temperature; it includes all the sensations arising from contacts, such as texture, pressure, stiffness, shape contours, and temperature (Klatzky & Lederman, 1993; Lederman & Klatzky, 1987).

Since it primarily includes abstract concepts, science is one of the courses in which students with visual impairment have the most academic difficulties (Karakoç, 2016). In particular, the lack of activities prepared using science materials that prioritize haptic and tactile sensations is one of the most common problems students with visual impairment face in science education (Koehler et al., 2018). In addition, the excessive visual elements in science textbooks are another difficulty faced by students with visual impairment in the education environment (Rule et al., 2011). For this reason, the use of teaching plans supported by assistive technologies, natural physical objects or three-dimensional haptic materials, and two-dimensional tactile documents in science courses is vital for students with visual impairment (Rule, 2011).

Active participation of students with visual impairment in science courses depends on classroom adaptations according to the curriculum and teaching strategies, the use of assistive technology in the classroom, materials developed according to individual needs, and activity designs that support cooperative learning to facilitate cognitive, psycho-motor and social interaction in students (Aslan & Savaş, 2020; Kızılaslan et al., 2019). In the literature, many studies have shown that these students can learn science subjects at the same level as their peers due to adaptations made from considering the students' individual needs in the activities and activity materials that support the teaching of students with visual impairment (e.g., Akarsu et al., 2021; Betts & Cross, 2010; Fraser & Maguvhe, 2008; Okcu & Sözbilir, 2019; Supalo et al., 2016; Zorluoğlu, 2017; Zorluoğlu et al., 2021). However, no study has been found on teaching sound insulation to students with visual impairment. On the other hand, it is frequently emphasized in the literature that tactile materials that support the learning experiences of students with visual impairment regarding scientific concepts and auditory materials that highlight the sense of hearing are not sufficient (Akakandelwa & Munsanje, 2012; Karakoç, 2016; Karakoç & Aslan, 2022; Sözbilir et al., 2016; Zorluoğlu & Sözbilir, 2016; Zorluoğlu & Sözbilir, 2017). Therefore, in this study, a science activity was developed for teaching the concept of sound insulation to students with visual impairment. The training was designed by considering the objective "*Explains the importance of sound insulation"* in the sixth grade Science Curriculum of the Ministry of National Education (MONE) (MONE, 2018). For this activity, which was prepared considering the individual needs of students with visual impairment, activity materials that highlight tactile and haptic sensations were developed. Thus, it was envisaged that students with visual impairment could learn the concept of sound insulation in a cooperative learning environment by using course information documents and activity materials.

Since the subject of science mostly includes abstract concepts and visuals, it is one of the most difficult courses for students with visual impairment to grasp (Karakoç, 2016). Furthermore, these students may have misconceptions about many science topics (Atila, 2017; Kızılaslan, 2019; Yazıcı et al., 2021). Therefore, they need to construct the knowledge themselves to prevent misconceptions. The 5E instructional model is effective in teaching scientific concepts and in supporting conceptual learning (Şeremet et al., 2022). Some studies (Küçük & Çalık, 2015; Şenel Çoruhlu & Çepni, 2016; Turgut & Gürbüz, 2011) have reported that the 5E teaching model is more effective than traditional teaching methods. In this study, an activity was implemented using the 5E instructional model considering the individual needs of students with visual impairment. By doing so, it was aimed that students with visual impairment could meaningfully organize the knowledge in their minds.

ACTIVITY IMPLEMENTATION

In this study, the 5E instructional model was used. This model was developed by Bybee (1997) based on the constructivist approach. This model was originally developed for "Universal Design for Learning" (Kızılaslan et al., 2019). Universal Design is expressed as "a teaching approach that aims to meet the needs of every student in a classroom and helps provide equal opportunity for all students to succeed." (Kızılaslan et al., 2019). In other words, it means that a teacher designs learning experiences to remove all barriers to learning and provides all students with equal opportunities to succeed. This approach suggests giving students multiple ways to interact with the activity materials and to help them understand why they need to learn what they have learned (Morin, 2014).

The stages of the 5E instructional model consist of engage, explore, explain, elaborate, and evaluate (Ayvacı & Bakırcı, 2012; Bybee, 1997; Trowbridge et al., 2004). *Engage* is the first stage that arouses students' curiosity, activates their prior knowledge, and introduces the topic to the students. At this stage, methods such as asking questions, watching videos, and brainstorming can be used. *Explore* is the stage that aims at allowing students to identify new ideas through hands-on learning activities. *Explain* is the stage that enables students to reveal the steps and solutions they followed to solve the given problem or to complete the task. *Elaborate* is the stage where students develop conceptual definitions and enrich what they have learned by applying these definitions to different situations. *Evaluate* is the stage that enables students to be aware of the knowledge they have learned to make a process-oriented evaluation.

The implementation of the activity plan for the 5E instructional model prepared in this study is given in detail below. In addition, *educational tips* were provided after each stage to encourage students to think critically about the topic and to support and facilitate the implementation of the activity in different settings. The activity was implemented by one of the researchers (the third author) who conducted the study *(henceforth referred to as the practitioner).* The practitioner has both practical and academic experience in science subjects with students with visual impairment. In this study, the practitioner has a facilitator role, asking questions and guiding students using his research and experience.

The participants included four students with visual impairment (blind). The participants were sixth-grade students studying at a state secondary school for the visually impaired. The activity was applied to all sixth-grade students in the school because the subject of the activity was among the sixth-grade learning outcomes. All participants had a diagnosis of total blindness (congenital). The age range of the students was between 12 and 14 years and the main writing tool they used was the braille slate with a stylus. Demographic information of the students is presented in Table 1.

Table 1. Demographic Information

Student	Gender	Age	Vision Level	Grade	Writing Tool
S_1	Male	12	Blind	6	Braille Slate
S_2	Male	13	Blind	6	Braille Slate
S_3	Female	12	Blind	6	Braille Slate
S_4	Male	14	Blind	6	Braille Slate

The researchers obtained the necessary legal (MONE) and ethical permissions (Ağrı İbrahim Çeçen University Ethics Committee) for implementing the activity. Thereafter, the practitioner carried out the activity with the students. It was performed in the students' home classroom during science lessons. The students, the practitioner, and a second researcher who took field notes during the process were present in the class.

Engage

At this stage, the practitioner provided a general introduction to the activity for drawing students' attention to the topic. For this introduction, he had the students listen to various sounds from different sources (e.g., rain, vacuum cleaner, car noise) and then asked from which sources these sounds were made. The students gave responses such as, "Oh… what is this sound?"(S_1), "I cannot remember what sound it is."(S_3), and "I know this sound, it is on the tip of my tongue."(S_4). Without providing any direction to these reactions, the students were asked, "What kind of problems may occur in humans if exposed to the high-intensity sound for a long time?", and students were allowed to brainstorm before the activity. All students were allowed to share their thoughts with their peers in the class.

After providing a brief introduction of the activity, the practitioner asked the question, "What can be done to avoid the disturbing effects of loud sounds?" to make students aware of the target, to draw their attention to sound insulation, to activate their preliminary knowledge about sound insulation and to make them think critically about how to provide sound insulation. Thus, it was attempted to increase the students' interest in the topic and their prior knowledge was activated. The following questions were asked to the students without interfering with their answers:

- What do you know about sound insulation?
- What are the benefits of sound insulation?

It was ensured that the students both brainstormed about these questions and discussed them with their peers. These discussions continued for 10 minutes. The students gave different answers to these questions, such as, "Sound insulation allows us to hear the other person."(S_2), and "Sound insulation prevents sound from leaving a room."(S_3). The students voluntarily answered the questions. However, the practitioner encouraged the students to answer all the questions to ensure the active participation of all students. It was observed that students mentioned topics related to sound insulation.

The practitioner prepared the students for the activity by mentioning that they could answer questions about sound insulation after the activity. Thereafter, the practitioner stated that the students would learn the concept of sound insulation from this activity. Furthermore, the practitioner underlined that the students would use tactile documents that highlight their haptic senses, they would take measurements using some materials and a sonometer, and they would learn about sound insulation and its properties based on the measurement results.

Educational Tip

To increase students' interest, start the alarm clock and let students hear the alarm clock before asking questions about sound insulation. Then put the working alarm clock inside the material made of plastic and close its cover. Next, have the students approach the questions from a different perspective by talking about sound transmission while the alarm clock is ringing.

Explore

Before starting the activity of this phase, the practitioner introduced the activity materials to all students and allowed the students to perceive and explore the properties of these materials by touching the activity materials (Photograph 1).

Photograph 1. Introduction of Activity Materials

The students examined the activity materials for 10 minutes. During this time, each student reviewed all the materials individually. Meanwhile, while recognizing the materials, in addition to the sense of touch, verbal explanations that each material had a different structure and their properties were different were provided to the students by the practitioner. The students examined the activity materials with excitement and curiosity. The practitioner observed that the students used expressions such as, “I wonder what materials are there? What are we going to do with them now?”(S_1), and “Shall we start right away?”(S_3). Some students asked for what purpose the materials would be used and what kind of activity they would perform. For example, the following question was asked: “How will we use these materials?”(S_2), and “Do we have any other boxes? What will we do with them?”(S_4). The practitioner gave informative answers to these questions. The practitioner explained that they would use a tactile document during the activity, and they would take measurements using some materials such as styrofoam, glass, cardboard, and a sonometer. After the activity materials were introduced, activity sheets (Appendix 1) were distributed to each student. Braille activity sheets were prepared for students with visual impairment (Appendix 2). The students were asked to read and analyze the activity document in question. Students were given 5 minutes for this task. After the students examined the activity papers, the practitioner verbally re-expressed the materials to be used in the activity. Thereafter, the Predict-Observe-Explain (POE) form (Appendix 3) was distributed to each student. The form was presented in braille format for students with visual impairment (Appendix 4).

The students were then asked to choose one of the materials made of glass, plastic, styrofoam, and cardboard, and it was envisaged that the students would understand the properties of a good sound insulation material. In the activity, an alarm clock was placed inside the different materials. The sound intensity of the alarm clocks emitted from each box was then measured using a sound measuring device (sonometer) placed at an equal distance after the alarm clocks inside the boxes sounded. Before starting the activity, for them to explore by touching, students were asked to note their opinions on which materials had better sound insulation properties in the “*Predict (P)*” section of the POE form (Photograph 2).

Photograph 2. Students Filling the POE Form

Here are some predictions of students: “I think the plastic box has better sound insulation.”(S_1), “I think it is styrofoam.”(S_2), “In my opinion, the glass box has better properties.”(S_3), and “I believe the cardboard box insulates better. Sometimes there is no sound from the cardboards. We don't even understand what's inside.”(S_4).

Once the students wrote their predictions on the POE form, the application was started. After placing the alarm clock inside each material, the students positioned the sonometer approximately 50 cm from the boxes (see Photograph 3).

Photograph 3. Activity Implementation Phase

The practitioner assisted the students as they placed the alarm clock inside the materials and positioned the sonometer 50 cm away. After the alarm clock sounded, the intensity of the sound emitted from each textile was measured together with the practitioner using a sonometer. The measurements showed that the sound insulation was 37dB for the glass box, 33dB for the plastic box, 30dB for the styrofoam box, and 32dB for the cardboard box. Since the application was made individually with each student, the practitioner shared the measured value from the sonometer with the other students in the class. Finally, the students were encouraged to note their observations in the “*Observe (O)”* part of the POE form. Students filled the POE form with a braille slate and stylus.

After the students noted their observation results, the practitioner asked, “Are your observation results the same as the predictions you made at the beginning of the lesson? Or are they different?” The students stated that there were differences between their predictions and the results of the observations they measured. For example, S_1 said, “Though I favored plastic, less noise came out of the styrofoam box. Styrofoam has better sound insulation.” S_3 stated, “I thought that glass could insulate better sound because we use it everywhere. However, glass was the most sound-transmitting object. Why did this happen? We can say that Styrofoam is better.” S_4 expressed, “Little sound comes from the styrofoam, not from the cardboard box. Maybe they all have different structures. Their conductivity is particularly different.”

The students asked the practitioner questions about the reasons for these differences, which included the following question: “Why might the styrofoam make less noise?”(S_1), “How could different measurement results be possible in all materials?”(S_2), and “Would it still produce the same results if it was in other materials?”(S_4). The practitioner continued the lesson by informing students that they would receive answers to these questions later in the lesson.

Educational Tip

Before putting the alarm clock in the materials and running it, have the students write their predictions about the variation of the loudness of the sound in different materials. While measuring the intensity of the sound coming from the sonometer materials, make sure that all students are quiet and share the value displayed on the sonometer with the students. In addition, make sure that all students record the value displayed by the sonometer on the POE form.

Allow enough time for all students to write their predictions and observations on the POE form. Before starting the lesson, prepare the activity documents according to the students' individual needs. For instance, you can present each stage of the POE form to students as a separate paper. If students with visual impairment also have “low vision”, you can submit the POE form in an enlarged format or by paying attention to color and contrast features.

Explain

The students shared their predictions and observations on the POE form with the whole class and they compared the results. The students used the following statements on this subject: “My prediction was styrofoam, and styrofoam is indeed very soundproofing.”(S_2), “I wonder why styrofoam transmitted less sound.”(S_1), and “I predicted that glass would make the best insulation, but it transmitted sound the most.”(S_3).

They were then asked to question the possible reasons for the difference between the measurement results and their estimates. The students used the following statements: “Sound transmission was more in glass and less in styrofoam, so styrofoam insulated better than glass. This may be because they are made of different materials.”(S_1), “There was a lot of sound transmission in glass, but less in styrofoam. Styrofoam seems to have better insulating properties than glass. I guess that's what happened when their structures had different content.”(S_2), “The styrofoam has a low measurement, but the glass has a large measurement. Accordingly, we can say that styrofoam is better. The structures of the materials are different from each other. That's why there were different results.”(S_3), and “The measurement was higher for styrofoam but less for glass. Styrofoam may have better insulating properties. Because their conductivity is different from each other.”(S_4).

Finally, the students were asked to note the answers to the following questions in the “*Explain (E)”* section of the POE form using the structured inquiry method.

- From which material were you able to hear the alarm clock sound more/less?
- Which material has better/worse sound insulation properties?
- Why do some materials have less sound insulation than others?
- What can be the general characteristics of sound insulation materials?
- What should be considered when choosing a good sound insulation material?

With these questions, it was aimed that the students would be able to think, analyze and explain why the intensity of the sound transmitted in different materials changed. The braille version of the POE form that was completed by the students is given in Appendix 5. Furthermore, its visualized version completed by the students in braille is given in Table 2.

Table 2. Answers in the POE Form of Students

	S_1	S_2	S_3	S_4
P	Plastic	Styrofoam	Glass	Cardboard
O	Plastic: 33dB Styrofoam: 30dB Glass: 37dB Cardboard: 32dB	Plastic: 33dB Styrofoam: 30dB Glass: 37dB Cardboard: 32dB	Plastic: 33dB Styrofoam: 30dB Glass: 37dB Cardboard: 32dB	Plastic: 33dB Styrofoam: 30dB Glass: 37dB Cardboard: 32dB
E	More than glass, less than styrofoam. So styrofoam insulated better than glass. To have different materials.	The glass was more, but the styrofoam was less. Looking at the glass, styrofoam has better insulation properties. This is because their structures have different content.	Styrofoam was low, but the glass was more. Accordingly, we can say that styrofoam is better. The structures of the materials are different from each other.	Styrofoam was more. The glass was scarce. Styrofoam may have a better insulating property. Their conductivities are different from each other.

After the students noted their opinions on the sound insulation properties of the materials on the form, they verbally shared their answers with all their friends. Here are some statements of students about why some materials had less sound insulation: “It might be because they are made of different materials.”(S_1), “I think it was because they had different substances.”(S_2), and “The contents of the materials are different from each other. That's why there were different results.”(S_3).

The students expressed their opinions about the general properties of sound insulation materials: “It should block the sound. It should not let the sound go out.”(S_4), and “The material should effectively carry out sound proofing so that it does not allow sound pass through it.”(S_2).

They talked about what should be considered when choosing a sound insulating material: “We should choose a material that blocks sound better. Not all materials have the same features.”(S_1), and “If we use materials that can block sound, we will disturb our neighbors less.”(S_3).

The practitioner did not interfere with the student's answers during this process. Afterwards, the course information document (Appendix 6) was provided to the students, and sound insulation was discussed with the students. Next, the students were allowed to use the observations and data obtained from the activity. Finally, the questions in the introduction section were again asked to the students.

Educational Tip

Give students enough time to review the Course Information Document. Then, interpret the embossed figure (see Appendix 6) in this document with the students.

Examine the activity data again, if necessary, by looking at whether the answers given by the students have changed and whether the mistakes have been corrected or not. Then, help the student correct their wrong learnings with their effort with hints and feedback.

Elaborate

After the activity, to help students better understand how sound insulation is realized, a brainstorming activity was held with the students using the Course-Information-Document. In particular, for students to focus on examples of sound insulation materials in daily life, they needed to understand the subject in depth by asking questions about how and from which materials sound insulation can be made at home, at work, and in cars.

- Why does the noise coming from the street to the house decrease in snowy weather?
- Where can we use sound insulation materials?
- Do the materials used in homes, workplaces, or schools affect sound insulation?
- What is the contribution of double-layered glass used in houses to sound insulation?
- What kind of sound insulation material can be used against the sounds coming from the neighboring walls?

It was observed that the students actively participated in answering these questions. All students were asked to respond. The students answered these questions by giving various examples of the applications of sound insulation in daily life. The answers to the first question were as follows: "Because the snow absorbs the sound too much…"(S_1), and "When it snows, sound does not vibrate. That's why there is silence."(S_3).

For the second question, the students said, "The walls of our classroom are built thick so that the sound does not come from outside."(S_4), and "There are windows in our house so we can sleep comfortably, and this reduces the sound."(S_2).

Some answers to the third question were as follows: "Yes, sir. Definitely. Otherwise, we could not stay in those places because of noise."(S_1), and "Yes. Otherwise, we would hear everything."(S_2). Regarding the fourth question, the students said, "Sir, they block the sound."(S_4), and "Absorbing the sound."(S_2).

Answers to the last question included, "We had the sheathing done. Actually, the house was cold, but we thought that it would also prevent the sound."(S_1), "Could it be the sponge you put on the side of the door?"(S_3), and "…I put blankets on the walls."(S_4).

In the elaborate stage, students should be able to combine the situations they encounter in daily life with the new information they have learned and be able to solve problems or produce solutions depending on their learning (Ayvacı & Bakırcı, 2012). The practitioner diversified the answers of the students and provided additional examples about the use of sound insulation in daily life, the areas of use and the materials to be used. During this stage, only brainstorming and providing additional explanations were considered a limitation of the elaborate stage.

Educational Tip

To make the elaborate phase more effective, a different activity can be designed for students with visual impairment. For example, a different activity can be designed regarding sound insulation by using some materials (e.g., melamine, sponge) different from the materials used in the study. Thus, the importance of sound insulation can be underlined.

Ask the students to touch the braille image in the Course Information Document to understand sound insulation better.

Explain that sound conceptually cannot propagate in space and that sound has the most negligible transmission in air. Explain that when choosing sound insulation materials, the reason for selecting materials with more air gaps in these materials is that sound cannot propagate in a vacuum. Because the sound cannot propagate in a vacuum, it will not be able to pass through the materials that have a void inside.

Evaluate

In the evaluation phase, both the efficiency of the activity and the learning of the students were analyzed using interview questions. For this, questions were asked about sound insulation and the materials used for sound insulation. In addition, to determine the learning levels of the students, the following questions were asked:

- What are the benefits of sound insulation in our daily life?
- Why is the sound intensity in some materials measured less/more than others?
- How do the materials use help create sound insulation?

It was observed that the students were able to define sound insulation and at the same time explain what sound insulation was. S_2 said, “Without sound insulation, there would be a lot of noise coming out of the factories.” It was observed that the ideas on why sound insulation is good or bad in different materials were developed. S_1 said, “The structure of the material was affecting the sound insulation.” In addition, it was observed that the students could provide explanatory information about the contribution of sound insulation materials to buildings and cars. For example, “Sir, cars make a lot of noise. We had an old car. It sounded like hrrr… But when we bought a new car, the sound disappeared.”(S_1).

In addition to these questions, the following questions were also asked to the students at the end of the activity to analyze their opinions and suggestions regarding the activity:

- Do you think the activity aims to teach the concept of sound insulation?
- What are the weaknesses of the activity?
- What parts did you find difficult to understand during the activity?
- Do you think the activity materials are understandable?
- How would you like to improve the activity to better understand the topic?

All students confirmed the appropriateness of the activity for teaching the topic. For example, “The activity helped us learn the subject.”(S_1), “The activity was on purpose, yes.”(S_2). They stated that they had fun during the activity and liked it very much. For example, S_3 said, “The activity was enjoyable, we really enjoyed it.”

Two students expressed their opinions about the missing points in the activity and how the activity should be improved, for example, “Maybe there could have been more materials.”(S_2), and “Maybe we could have practiced in the lab, not in the classroom.”(S_4). These views can be interpreted as an indication of the situation, which was stated as a limitation in the elaborate stage. The use of different materials and activities in the elaborate stage help consolidate knowledge.

All the students said that the activity was easy and understandable and that all science lessons should be taught in this way. They also stated that they understood and conceptualized better with such an activity. Regarding this finding, the following example statement was noted: “The activity was easy, we understood what was explained. In fact, it would be better if we did this in other lessons as well.”(S_4), “We enjoyed the work we did. It would be great if we could do other science lessons with experiments like this.”(S_1).

CONCLUSION and SUGGESTIONS

The use of haptic materials and two-dimensional tactile documents in science courses is crucial for students with visual impairment (Rule, 2011). In this study, an activity in which haptic sensations are emphasized was designed to enable students with visual impairment to learn the concept of sound insulation. In addition, the activity was supported by a course information document. In this way, tactile and haptic perceptions of students with visual impairment were highlighted (Alnfiai & Sampalli, 2017). In the study, the activity designed by the researchers was used with four blind students. Care was taken to ensure that the application process was individualized. Thus, attention was paid to students with visual impairment characteristics and needs. As a result of the application, it was determined that the students who participated in the study achieved the targeted learning objectives regarding the concept of sound insulation. Some studies in the literature report that making appropriate adaptations to individual needs in activities and activity materials that will support teaching enables students with visual impairment to understand science subjects better (e.g., Akakandelwa & Munsanje, 2012; Betts & Cross, 2010; Fraser & Maguvhe, 2008; Kapucu & Kızılaslan, 2022; Okcu & Sözbilir, 2019; Supalo et al., 2016; Zorluoğlu, 2017; Zorluoğlu & Sözbilir, 2016; Zorluoğlu & Sözbilir, 2017; Zorluoğlu et al., 2021). Accordingly, it can be said that the findings obtained from this study are compatible with the literature.

During the activity, it was observed that all students actively participated in the activity. These observations were noted in the self-reports of the practitioner and the field notes of the second (other) researcher in the class. Although this is considered a limitation, the students' willingness to talk during the activity, their responses to the practitioner, and their active participation in the activity strengthen these observations.

When the effectiveness of the activity was examined at the end of the process, it was found that the students with visual impairment could express valid opinions about sound insulation and could explain the importance of material properties in sound insulation (again based on the statement of the researcher and practitioner). In addition, it was observed that the ideas of why the sound insulation is high or low in different materials were developed.

Furthermore, regarding their opinions about the activity, students with visual impairment mostly found the activity entertaining and instructive. In addition, they stated that the activity was suitable for teaching the concept of sound insulation. These findings reveal that the activity served its purpose, and it can be said that it aroused interest and curiosity in the students. Moreover, it may be beneficial to use similar teaching methods and strategies in other science teaching settings. On the other hand, all of the students stated that the activity was easy and understandable and wanted all lessons to be taught in this way. They also emphasized that they achieved a more efficient and coherent learning experience. Therefore, it can be said that students with visual impairment should be provided with teaching that embodies the knowledge, that helps them gain experiences of learning by doing, and that different strategies support the learning process. These initiatives can increase the interest and desire of students in the course, and at the same time, they can enable students to have more permanent learning experiences.

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Appendix 1

Worksheets

Activity Title: Let's explore sound insulation materials.

Purpose of the Activity: Let's explore the properties of sound insulation materials

Materials to be Used in the Activity

1. Glass jar
2. Plastic container
3. Styrofoam box
4. Cardboard box
5. Alarm clock
6. Sound measuring device (Sonometer)

Procedures:

1) Place the sonometer 50 cm away from the alarm clock.

2) In the *Predict* section of the POE form, write your prediction regarding from which box the loudness of the sound may be less when the alarm clock is placed in a glass jar, plastic box, styrofoam box, and cardboard box.

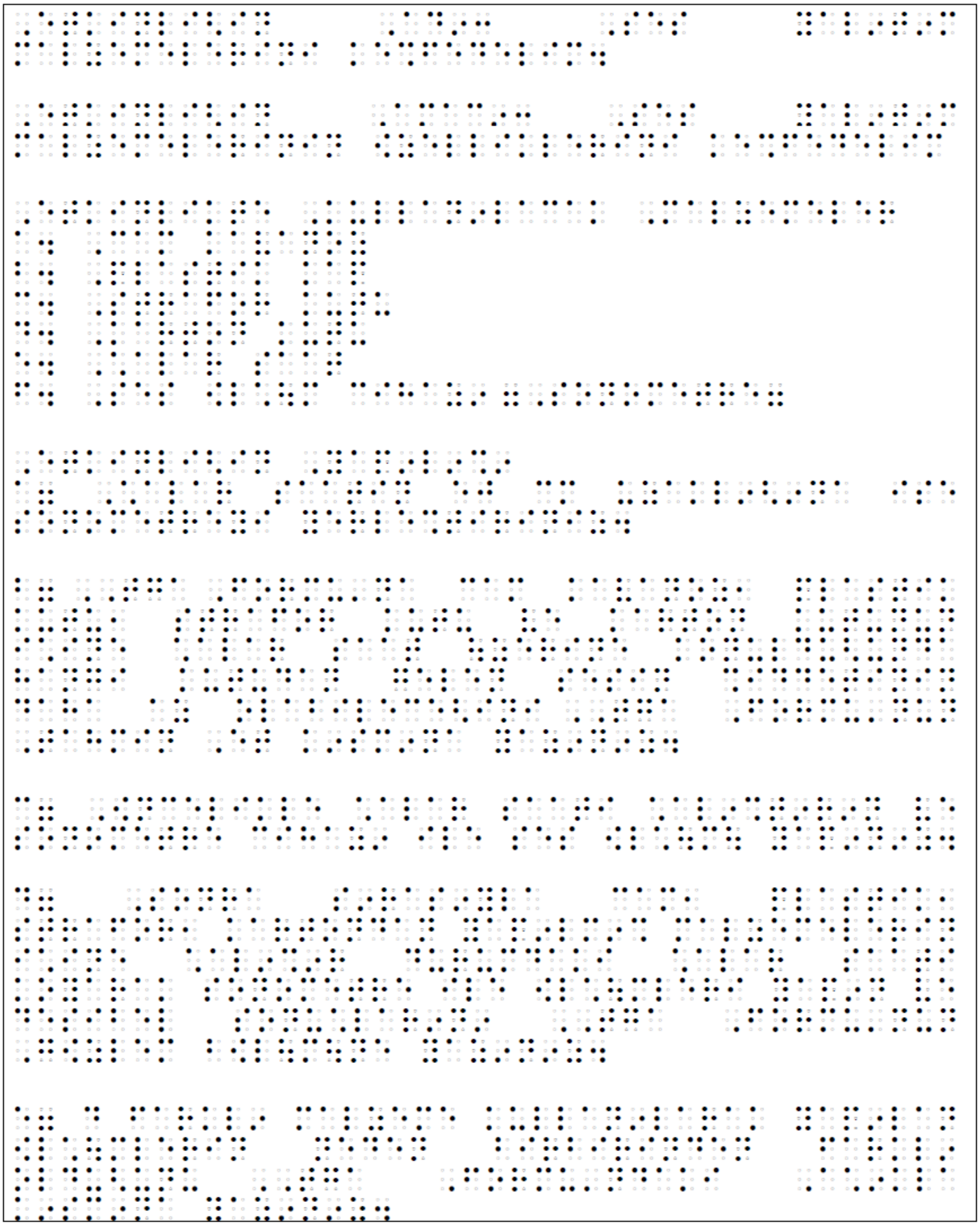
3) First, start the alarm clock and measure the sound with the sonometer device.

4) Then, put the alarm clock inside the materials made of glass, plastic, styrofoam, and cardboard, and make the measurements with a sonometer when the alarm is on. Write the decibel results in the *Observation* section of the POE form.

5) Write in the *Explain* section of the POE form why the measurements made using 4 different materials are different from each other.

Appendix 2

Worksheets
(Braille Version)



Appendix 3

POE Form

PREDICT
OBSERVE
EXPLAIN

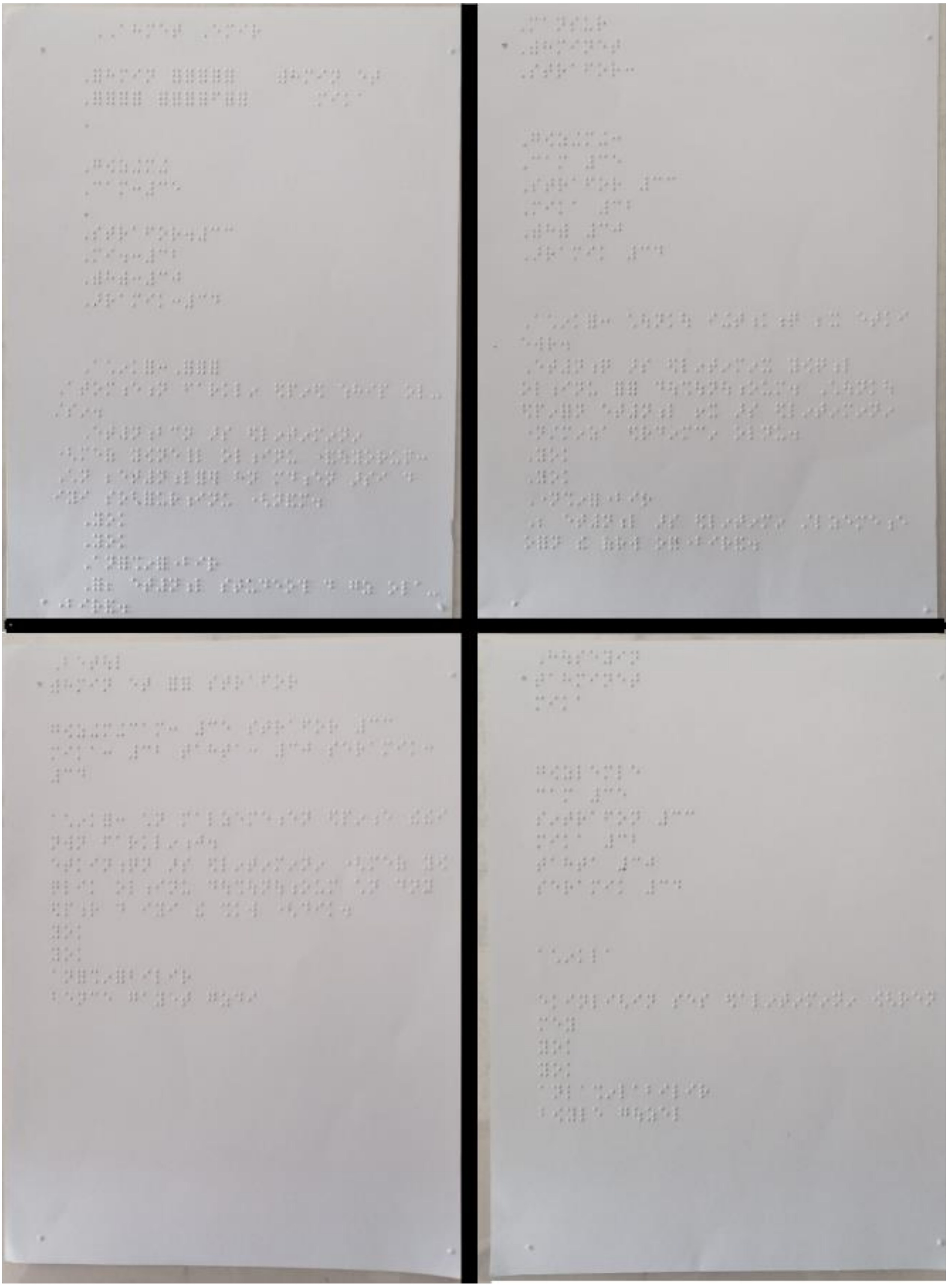
Appendix 4

POE Form
(Braille Version)

⠠⠠⠞⠁⠓⠍⠊⠝ ⠑⠞
⠠⠠⠛⠪⠵⠇⠑⠍⠇⠑
⠠⠠⠁⠡⠔⠅⠇⠁

Appendix 5

POE Form Completed by Visually Impaired Students



Appendix 6

Information Document

Sound insulation

Some of the sound waves interacting with the material are reflected by the material, some are absorbed and some are transmitted. Some materials absorb sound more, while some materials absorb sound less. This may vary depending on the type of substance used. For example, a metal object absorbs sound less than a wooden object. Therefore, materials that absorb sound more are preferred in sound insulation.