Multimedia Enriched Practices

Development and Application of Audio Tactile Electronic Material for Students with Visually Impaired

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Abstract: *In this study, an audio, tactile, and electronic material for teaching the concepts of "Moon Phases" and tactile matching cards for evaluation were developed considering the needs of students with visually impaired (SVI). These developed materials were based on the STEM method. This study is a "design and development research". "Design and Development Research" is the research related to the development of products and tools and consists of the stages of development, implementation and evaluation of teaching materials, educational software and learning systems to be used in learning and teaching processes. In this study, a material was developed and applied. The study group of the research consists of 5th grade students in a middle school for the visually impaired in Istanbul. 8 students including 3 girls and 5 boys participated in the study. After the application was made with the developed material, the students' opinions about the material were taken with the semi-structured interview form prepared by the researchers. The data obtained from the interviews were analyzed with the content analysis method, and suggestions were presented in the light of the findings.*

Keywords: *Braille alphabet; science teaching; Moon phases; middle school students*

Introduction

Students with visually impaired (SVI) use different methods to acquire new information according to sighted individuals. SVI can only learn through special teaching methods what others learn by seeing, without realizing it, in daily life (Kizilaslan et al, 2016). This difference in methods causes the visually impaired individual to be one step behind in terms of education

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level. In this respect, SVI are in a disadvantaged group compared to their peers in science lesson as in other lessons. They have difficulties in learning science concepts, especially by doing experiments (Kizilaslan et al, 2020). Although SVI perceive the world differently with their sense organs, they have the same cognitive abilities as their peers. It is reported that they can be master high-level science concepts (Kumar et al 2001; Plazar, 2015). Since science and mathematics courses are based on visual concepts, they are inaccessible for SVI. Either there is no suitable format material or the materials are too expensive for a public school (Beck-Winchatz et al, 2008; Sahin et al; 2009). Therefore, it is observed that visually impaired children fail in skills that require abstract thinking. Materials that develop abstract thinking should be put forward (Zorluoglu & Sozbilir, 2017). It is important to actively involve SVI in science teaching. It is necessary to convey science not with explanation techniques, but with materials that will appeal to other senses (Plazar, 2015). Kizilaslan et al. highlighted, SVI use tactile and kinaesthetic inputs to obtain information (Kizilaslan et al, 2020). Therefore, science and laboratory education should be transformed into Braille and electronic materials. Tactile diagrams, graphs, audible and embossed materials should be given the students (Sözbilir et al, 2015).

Visually impaired students lag behind both cognitive and instructional in the science lesson, where visual information is used intensively (Kizilaslan et al, 2020). When the literature is examined, it is seen that material studies were conducted with SVI for science lessons. Science teaching of SVI was studied by Mayo (2004) with Braille embossed texts and figures. Mayo examined the effect of the material he used on students' perception of abstract concepts in chemistry lessons. In their study, Wild et al. (2013) aimed that SVI learn the sound unit, which has abstract concepts, better. They studied with 13 SVI, 5 girls and 8 boys, studying at middle school. In the study, SVI created concrete materials such as simple telephones by using boxes, ropes and various materials. At the end of the training day, summaries in Braille were written to reinforce what they learned. Cole and Slavin (2013) developed a device for the science laboratory of students with low vision. With this device, students were able to set up the experimental setup. As a result of the experiment, they were able to read and save the data. Kizilaslan and Sozbilir (2017) worked with a total of four 8th-grade students, two of whom had never seen and two of whom had low vision, from the state middle school. They identified the needs for learning the concepts in the "States of Matter and Heat" unit. It has been observed that materials for SVI give positive results in teaching science concepts. Sozbilir and Zorluoglu (2017) worked with SVI on the densities of insoluble liquids. They have developed materials that will activate students' senses of touch and hearing. The study group consisted of eight SVI, five boys and three girls, from 6th-grade students. It was concluded that the study was successful in teaching the subject of "density of insoluble liquids" to SVI.

When the astronomy and space education of visually impaired students is examined, the most comprehensive study we encounter is the NASA-supported study (Beck-Winchatz & Ricobbono, 2008). Applied space science activities based on Braille and tactile inquiry have been developed within the scope of the Space Exploration Experience Project (SEEP) for the SVI. This study was carried out in the summer of 2004-2005 with SVI studying in middle or high school at Yerkes Observatory. Students worked with computer-controlled telescopes. They used tactile image printers and capsule paper to transform the images they obtained into a tactile form. Later, they combined their tactile images in the book "See the Universe" by describing them in the Braille

alphabet. This study revealed that visually impaired students can do successful studies in science, technology, engineering, and mathematics (STEM). Beck-Winchatz and Ostro (2004) used scale models for SVI to learn about asteroids in their NASA-supported studies. Students examined these models by touching and measured the distance between them with a Braille meter tape. As a result of the study, it was seen that the SVI could understand the asteroids, the estimated distances between them and their displacements. When the international studies were examined, no study on the Phases of the Moon was found with SVI.

STEM education focuses on the hands-on process of designing solutions to complex problems using new technologies. STEM is a meta-discipline that breaks down traditional barriers (Kennedy & Odell, 2014). It is known that the science lesson can be associated with other disciplines with the STEM method, and the STEM learning environment facilitates students' learning and increases their skills (Güldemir & Çınar, 2017). Considering all these, it comes to mind as a question whether materials that will eliminate the disadvantages of SVI can be produced with STEM studies.

This study was carried out to measure whether SVI have learned the subject of "Phases of the Moon" in the "Sun, Earth and Moon" unit and to measure the usefulness of teaching with a material that will fill the deficiency in this field. The hypothesis of this study was determined as "An audio-tactile electronic material can be developed for teaching the subject of the Phases of the Moon for SVI and tactile matching cards can be prepared for evaluation purposes".

Research Importance

When the researches for SVI are examined, it has been determined that although studies have been carried out in this field, no audio, tactile electronic material designed for teaching the phases of the Moon and applied with SVI. In this study, an audio-tactile electronic material was developed for the teaching of the concepts of the phases of the moon, taking into account the needs of SVI. This material is an innovative design that can be a candidate to solve the problem of inadequacies of simple materials. In the study, it was also aimed to get students' opinions about the material after the material was used with students.

Research Purpose

In this study, it is aimed to develop an audio, tactile and electronic teaching material and to determine student opinions about this material. For this purpose, the problem statement of the research is defined as: "*Can an audio, tactile, electronic material be developed for teaching concepts about the phases of the Moon?*".

Method

This study is a 'design and development research'. Design and Development Research (DDR) is a research method that aims to reflect knowledge directly to solution-oriented applications, beyond having knowledge. Studies such as the development, implementation and evaluation of teaching materials, educational software and learning systems to be used in learning and teaching processes can be given as examples of such research. DDR can also be used for product (tool, material, etc.), model, or process development research in natural and social sciences. However, this method is especially recommended for research in the field of instructional design and technology (Büyüköztürk, 2020).

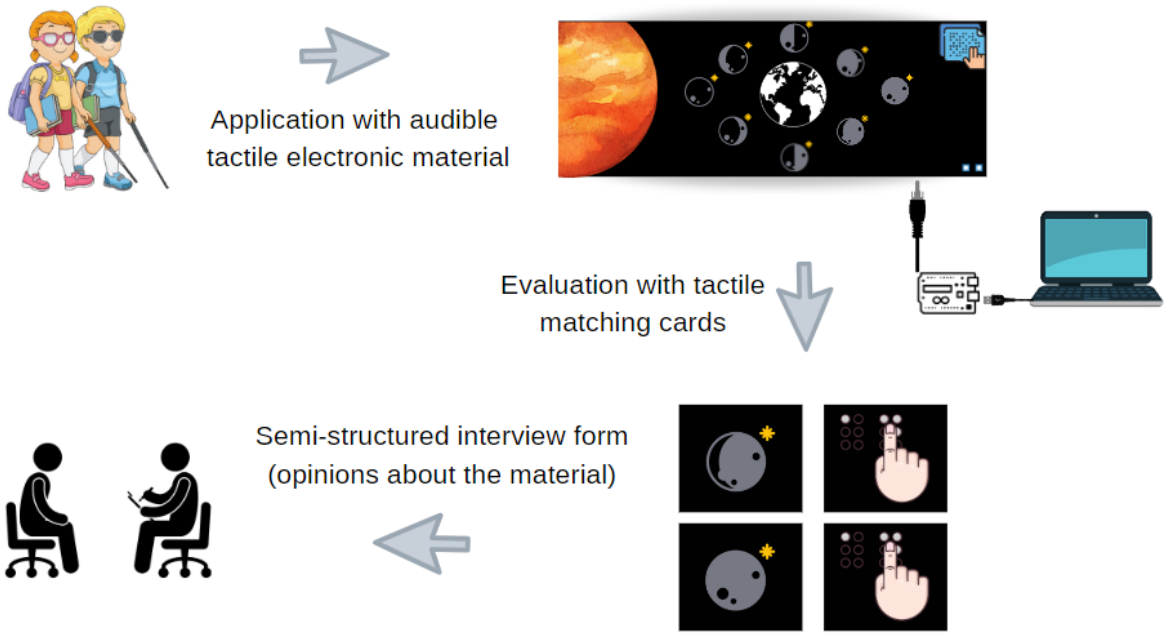
In this study, semi-structured interview form prepared by the researchers were used as data collection tool. Semi-structured questions were prepared to collect the opinions of the

visually impaired students about the audio-tactile electronic material. These questions were applied through face-to-face interviews with the students. Although the researchers prepare semi-structured interview form questions before the interview, they may ask new questions depending on the flow of the interview in order to get detailed answers (Karasar, 2009). The students' opinions about the developed material were collected through semi-structured interview questions prepared by the researchers (see Appendix 1).

Methodology

Figure 1

The methodology of the entire study text



Application of the Study

In this study, material was developed considering the disadvantages of SVI. The developed material was studied together with the students. Finally, the opinions of SVI about the material were collected.

For this purpose, the study was carried out in two stages. The first stage is the development of an audio-tactile electronic material for the purpose of teaching the concepts of "The Phases of the Moon" to the SVI. The steps followed for material design are as follows:

1. The four primary and four intermediate phases of the Moon are embossed on a special aluminium plate, considering the Sun, Earth and Moon's dimensions, with a special technique (see Appendix 4 for an anecdote on the history of science and engineering for the heliocentric system and the first map of the Moon.)

2. Each embossed figure is numbered in the Braille alphabet.
3. The names of the numbered figures are embossed on the right side of the plate in Braille.
4. A volume button has been added next to each embossed shape. When this button is pressed, the sound recorded by coding with Arduino gives information about the figure (see Appendix 2).
5. The phases of the Moon were embossed separately on an aluminium plate of the appropriate size to contain eight tactile matching cards, and the names of each phase were embossed in Braille on eight different tactile matching cards.
6. In order to prevent the material from collapsing, the embossed shapes are filled with silicon and mounted on a material called photo block.

The material development phase is associated with the STEM steps as:

- Determining the dimensions of the aluminium plate "Mathematics"
- Placing the phases of the Sun, Earth and Moon on the plate "Science",
- Adding volume buttons to the aluminium plate with Arduino "Technology and Engineering"

The second stage of the study is the application of the developed material. The first step for this is to determine the working group. The study group was determined by convenience sampling, which is one of the non-random sampling methods. The sample is chosen from easily accessible and applicable units due to the limitations in terms of time and workforce in convenience sampling (Büyüköztürk et al., 2014). Considering that the researchers reside in Istanbul, Turkey, the study was carried out in a middle school for the visually impaired students in Istanbul, in order to eliminate the time and labour limitations for practice. A total of 8 students, 3 girls and 5 boys, participated in the study.

The opinions of the SVI about the innovative material developed for the subject of "Moon Phases" were collected with a semi-structured interview form prepared by the researchers. After the audio tactile electronic material and tactile matching cards were developed, a lesson was conducted with the SVI. After the application with the material tactile matching cards were distributed to the students in order to observe and evaluate whether the students learned the subject or not. At the end of the study, a semi-structured interview form was applied to determine the opinions of the SVI about the audio-tactile electronic material developed. In the analysis of the data obtained at the end of the interview, descriptive content analysis methods were used in the study. In order to ensure validity in the analysis of the data, the results of the analysis were reviewed by two science education experts. In addition, the study was presented as an oral presentation in "3rd International STEM Education Conference". After the presentation, the analyses were revised by taking into account the discussions and suggestions.

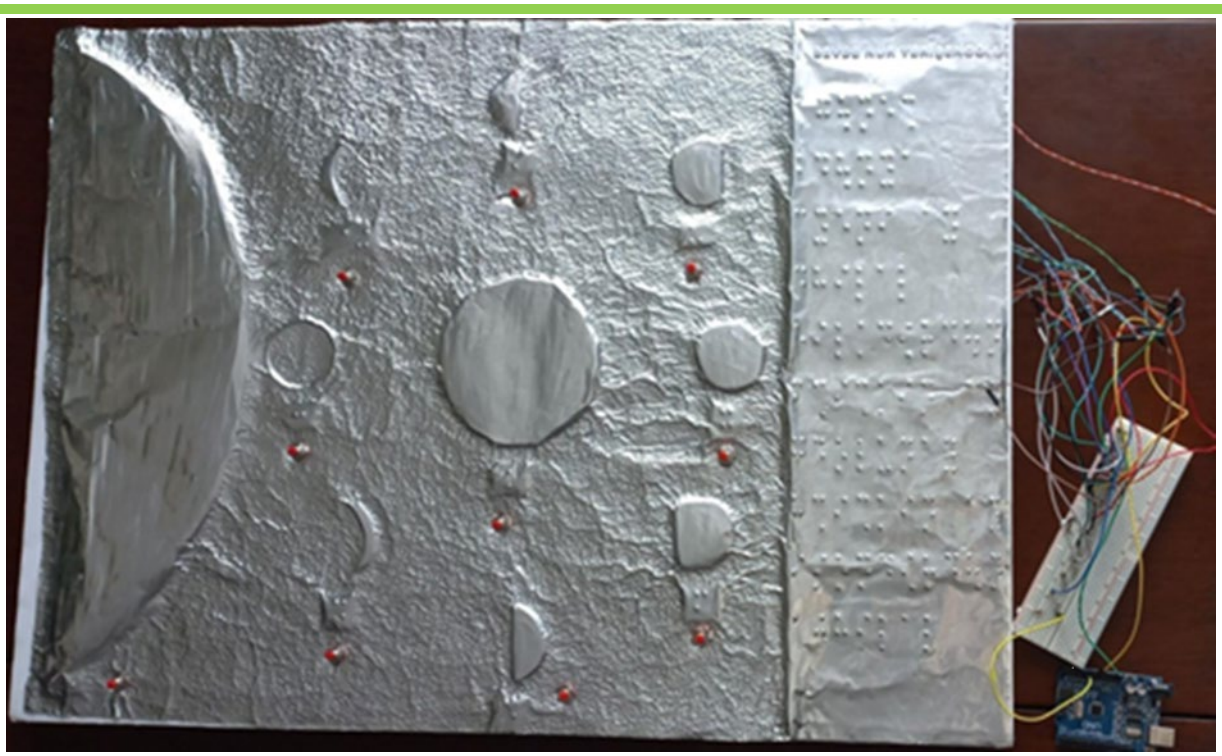
Findings

The material developed in the study and matching cards are presented below:

Material

Figure 2

Audio Tactile Electronic Teaching Material



The material developed is given in the image above. Audio Tactile Electronic Teaching Material includes reliefs of part of the Sun (far left), Earth (middle), and phases of the Moon. Braille numbering is shown below each figure. The right part of the material is reserved for numbers. Each number indicates which shape it represents. Number and shape names are embossed in Braille. Under each figure, there is a voice button that gives information about the figure. The material can be accessed via Video (https://youtu.be/7koD3Zkurp4). The video and code image for the material are also available on the journal's website.

Cards

Figure 3

Tactile Matching Evaluation Cards

The cards developed are shown in the image above. Eight Moon phases are embossed. The names of the eight Moon phases are embossed.

The data of the semi-structured interview form applied in the study are presented below in Table 1:

Table 1
Semi-Structured Interview Form Results

Meaning Unit	**Subcategory**	**f**	**%**
Ideas About the Material	Good	3	37
	Very nice	5	63
Effect of the Material on Teaching the Subject	Reminded the phases	5	63
	Reminded the shapes	1	13
	Taught the subject more	2	24
Difficulties Encountered While Using the Material	Braille script	4	48
	New moon and full moon phases	1	13
	No difficulty	3	38
Need for a Guide While Using the Material	No need	4	48
	In Braille	3	38
	In Braille and shapes	1	13
Feelings of Students While Using the Material	Walking in the sky	1	13
	The material is beautiful	1	13
	Being in space	2	23
	Enjoyable	1	13
	Happy	3	38
	Excited	1	13
Points Where Changes are Requested in the Material	Magnification of the sun	1	13
	Writing Braille on a tablet	1	13

	Reducing Braille	2	24
	No change	4	50
Ideas on Using the Material in Science Lessons and Other Lessons	Beautifying the lesson of the material	1	13
	The material makes it easier to learn the subject	6	74
	The need for the material for teaching	1	13

According to the data in Table 1, in the "Ideas About the Material", %37 of the students stated that the material was "Good" and %63 of them "Very nice". In the "Effect of the Material on Teaching the Subject", %63 of the students stated that it reminded the phases, %13 reminded the shapes, %24 of them stated that the material taught the subject more. In the "Difficulties Encountered While Using the Material", 48% of the students stated that they had difficulty in reading Braille, 13% said that they had difficulty in understanding the new moon and full moon phases, and 38% said that they had no difficulty. In the case of "Need a Guide While Using the Material", 48% of the students stated that they did not need a guide, 38% of the students said that they needed a guide in reading Braille, and 13% of the students stated that they needed a guide both in reading Braille and in shapes. When we look at the "Feelings of Students While Using the Material", it is seen that %13 of the students feels the material is beautiful, %23 of them is in space, %13 is having fun, %38 is happy, %13 is feeling excited. In the "Points for which Changes are Required in the Material", %13 of the students wanted the Sun to be enlarged, %13 wanted the Braille script to be written on a tablet, %24 wanted the Braille script to be reduced; It is seen that %50 of them do not want to be changed. In the "Ideas on Using the Material in Science Lessons and Other Lessons", 13% of the students stated that the material should be used in the Science lesson and other lessons because it makes the lesson beautiful, 74% of the students stated that the material facilitates learning the subject, and 13% of them stated that the material should be used in the science lesson and other lessons.

Discussion and Conclusion

In this study, "Audible Tactile Electronic Teaching Material and Tactile Matching Evaluation Cards" were developed in order to learn the phases of the Moon by considering the disadvantages of 5th-grade SVI. Thus, the subject of the phases of the Moon, which is unobservable and abstract, has been turned into concrete for disadvantaged students and their learning has been facilitated. Sozbilir and Zorluoglu (2017) studied the densities of insoluble liquids with SVI in their studies where they developed materials that would activate students' senses of touch and hearing. At the end of this study, it was concluded that the material

developed was successful in teaching the density of insoluble liquids to SVI. It was thought that the material to be developed on the phases of the Moon, which is an abstract subject such as the density of different liquids, would also be successful. In this study, students were able to concretize the phases of the Moon by examining it with a material. It has been observed that they have improved their knowledge on this subject.

During the application, it was observed that a student did not know the Braille alphabet, and some students were weak in this regard. Tactile matching cards could not be studied with the student who does not know the Braille alphabet. This reveals that materials consisting only of embossed figures and Braille alphabet are insufficient for students. The study by Yazici et al. (2021) supports this result. According to Yazici et al. (2021), SVI need embossed materials that they can examine by touching inside and outside the classroom and written sources printed in Braille. In the interviews of Yazici et al. (2021) with teachers, they stated that the greatest need of teachers for the lesson is materials suitable for the disadvantages of students. Teachers demanded that these deficiencies be met immediately. When we look at the answers to the semi-structured interview questions in this study, it comes to the fore that the study group students also consider this kind of material necessary for teaching. They stated that it is necessary to use the material both in science lessons and in other lessons, as it facilitates learning the subject.

Kumar (2001) and Özkan (2013) stated in their studies that inadequacies cause fear of the laboratory in SVI, and that it is necessary to prevent practicing with the help of someone only. It has been argued that laboratories should be aimed at the disadvantages of SVI and that they should be intertwined with technology so that students can do the applications alone. Based on this, in the material developed in this study, embossed shapes, Braille writing and voice buttons were used to enable students to learn the subject without the need for a guide. Considering the opinions about the material, it was seen that half of the students in the study group stated that they did not need a guide. It was observed that some of them stated that they needed a guide in reading Braille. It was seen that this was related to the use of a larger font than the font that the students were accustomed to while preparing the material.

After the application was made with the developed material, it was observed that the SVI followed the subject carefully. In addition, when their opinions about the material were taken, they stated that they enjoyed the subject with the material, they were excited, and that the material taught the subject better. Okcu and Sozbilir (2016) stated in their study that many subjects are not understood by SVI because no materials or tools are used in science lessons. Therefore, they said that the students were exposed to many stimuli and could not follow the subject due to distraction. In addition, in the interviews they made with the students, it was seen that the SVI could not feel themselves actively in the lesson due to the lack of materials and activities adapted or arranged for the visually impaired. This study is in agreement with the study of Okcu and Sozbilir (2016). In both studies, it is seen that an efficient application will be made if appropriate materials are presented for SVI.

When the students' opinions about the material were taken, it was seen that they wanted the Braille text in the material to be reduced. The reason for this is the large font size of the Braille alphabet in the material prepared in the study. Because the font size of the Braille alphabet used by students is smaller. This made it difficult for the student to read. If Braille alphabet is to be used in a material to be prepared, it is recommended that the font size of the letters be in a size

that students can read a letter with their fingertips. As a matter of fact, Baloğlu (2013) also stated that in Braille studies, it is necessary to focus on fingertip movements, not symbols.

As a result, visually impaired students can be taught "Phases of the Moon" and other space topics with an audio-tactile electronic material. This study also contributes to the studies in the field that support this.

Limitation and Implications

This study was carried out with SVI. If you have not worked with SVI before, it is recommended to visit schools before such a study. During this visit, teachers and students should be interviewed. Educational materials and activities, if any, should be examined.

If the material in the study is developed, it can be shown in the material that the Moon rotates around its axis and revolves around the Sun with the Earth. This reveals the conclusion that the study can be improved and innovative.

Declaration of Interest Statement

All authors state that there is no conflict of interest in this study.

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References

Baloğlu, T. (2013). *Görme Engellilere Okuma Yazma Öğretim Kılavuzu* (pp.40-42). Ankara: Millî Eğitim Bakanlığı Özel Eğitim ve Rehberlik Hizmetleri Genel Müdürlüğü. https://orgm.meb.gov.tr/meb_iys_dosyalar/2014_09/10100531_grmeklavuzu.pdf

Beck-Winchatz, B., Ostro, S.J., (2004). Using Asteroid Scale Models in Space Science Education for Blind and Visually Impaired Students. *The Astronomy Education Review*, 2(2), 118-126. s. https://doi.org/10.3847/AER2003018

Beck-Winchatz, B., Ricobbono, M.A. (2008). Advancing participation of blind students in Science, Technology, Engineering, and Math. *Advances in Space Research*, 42(11). https://doi.org/10.1016/j.asr.2007.05.080

Büyüköztürk, Ş. (2014). *Deneysel desenler: Öntest-sontest, kontrol grubu, desen ve veri analizi* (pp.1-19). Pegem A. https://doi.org/10.14527/9789756802434

Büyüköztürk, Ş., Akgün, Ö.E., Çakmak, E.K., Karadeniz, Ş., Demirel, F. (2020). *Eğitimde Bilimsel Araştırma Yöntemleri* (pp.20). Pegem Akademi https://doi.org/10.14527/9789944919289

Cole, R. A. and Slavin A. J. (2013). Use of a video assistive device in a university course in laboratory science: A Case Study. *Journal of Visual Impairment and Blindness*, 107(4), 311-315. (EJ1017596). ERIC. https://files.eric.ed.gov/fulltext/EJ1017596.pdf

Güldemir, S., & Çınar, S. (2017). Fen bilimleri öğretmenleri ve ortaokul öğrencilerinin STEM etkinlikleri hakkındaki görüşleri. In *ULEAD 2017 Annual Congress: ICRE* (Vol. 280, p. 286). https://doi.org/10.24130/eccd-jecs.1967202152295

Karasar, N. (2009). *Bilimsel araştırma yöntemleri* (pp.210-220). Nobel.

Kızılaslan A. Sözbilir, M., Bülbül, M.Ş. (2016). *Düşük düzeyde engeli olan öğrencilere öğretim*. M. A. Mastropieri, & T. E. Scruggs (Edt). M. Şahin. & T. Altun. (Çeviri Ed.), Kaynaştırma sınıfı: Etkili farklılaştırılmış öğretim için stratejiler içinde (pp.77-100). Nobel Yayıncılık.

Kızılaslan, A. & Sözbilir, M. (2017). The need analysis of students with visual impairment related concept of the 'state of matter and heat' units. *Atatürk Üniversitesi Kazım Karabekir Eğitim Fakültesi Dergisi*, 35, 274-290. https://dergipark.org.tr/tr/pub/ataunikkefd/issue/33367/331718

Kızılaslan, A. Zorluoğlu, S. Sözbilïr, M. Teke, D. (2020). Analysis of science activities developed for students with visually impaired: Matter and heat. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi*, 8 (1), 19-32. https://doi.org/10.18506/anemon.524012

Kumar, D., Ramasamy, R. & Stefanich, G. (2001). Science for students with visual impairments: Teaching suggestions and policy implications for secondary educators. *Electronic Journal of Science Education*, 5(3). (ED464805). ERIC. https://files.eric.ed.gov/fulltext/ED464805.pdf

Mayo, P. M. (2004). *Assessment of the impact chemistry text and figures have on visually impaired students' learning* [Unpublished doctoral dissertation]. Purdue University.

MEB (Millî Eğitim Bakanlığı). (2021a). *Ortaokul fen bilimleri 5. sınıf ders kitabı.* Millî Eğitim Bakanlığı Yayınları.

MEB (Millî Eğitim Bakanlığı). (2021b). *Ortaokul fen bilimleri 7. sınıf ders kitabı.* Millî Eğitim Bakanlığı Yayınları.

MEB (Millî Eğitim Bakanlığı). (2021c). *Ortaokul fen bilimleri 7. sınıf ders kitabı.* Millî Eğitim Bakanlığı Yayınları.

Okcu, B., Sözbilir, M. (2016). "Teaching of the unit "electricity in our lives" to 8th-grade middle school students with visual impairment: Let make a magnet". *Journal of Bayburt Education Faculty*, 11(1), 202- 223. https://dergipark.org.tr/tr/pub/befdergi/issue/23129/247060

Özkan, E. (2013) Investigation of The Self Efficacy, Social Anxiety, Coping Skills and Environment Effect of Social Participation in Adult Blind People and People With Low Vision [Unpublished Master's Thesis]. Hacettepe Üniversitesi

Plazar J. (2015). Učenje naravoslovja za slepe in slabovidne učence. *Journal of Elementary Education*, *8*(4), 159-176. https://journals.um.si/index.php/education/article/view/401

Sözbilir, M., Gül, Ş., Okçu, B., Yazıcı, F., Kızılaslan, A., Zorluoğlu, S. L. & Atilla, G. (2015). Trends in Research papers about teaching science to visually impaired students. *Abant İzzet Baysal*

Üniversitesi Eğitim Fakültesi Dergisi, 15 (1), 218-241. https://doi.org/10.17240/aibuefd.2015.15.1-5000128604

Sözbilir, M. ve Zorluoğlu, S. L. (2017). Birbiri İçinde Çözünmeyen Sıvılarda Yoğunluk Kavramının Görme Yetersizliğinden Etkilenen Öğrencilere Öğretimi. *Eğitimde Kuram ve Uygulama*, 13(2), 211-231. https://doi.org/10.17244/eku.310219

Şahin, M., Yorek, N. (2009). Teaching Science to Visually Impaired Students: A Small-Scale Qualitative Study. *US-China Education Review*, Volume 6, No.4 (Serial No.53). (ED505732). ERIC. https://files.eric.ed.gov/fulltext/ ED505732.pdf

Wild, T. A, Hilson, M. P. and Hobson, S. M. (2013). The Conceptual Understanding of Sound by Students with Visual Impairments. *Journal of Visual Impairment & Blindness*,107-116. https://doi.org/10.1177/0145482X1310700204

Yazıcı, F., Gül, Ş., Sözbilir, M., Çakmak, S. ve Aslan, C. (2021). Determining the teaching needs of students with visual impairment in the sixth-grade fort the science course. *Milli Eğitim Özel Eğitim ve Rehberlik Dergisi*, 1(1), 26-64. https://dergipark.org.tr/tr/pub/ozelegitimrehberlikdergisi/issue/65815/1031508

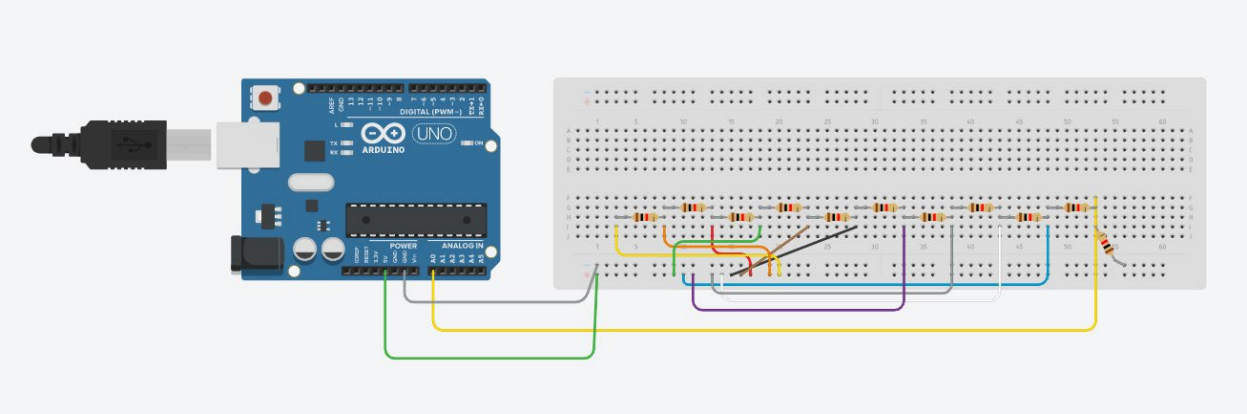
Zorluoğlu, S. L., ve Sözbilir, M. (2017). Learning support needs of visually impaired students. *Trakya Üniversitesi Eğitim Fakültesi Dergisi*, 7(2), 659-682. https://doi.org/10.24315/trkefd.279369

Appendix 1: Semi-Structured Interview Form for the Opinions on the Material

1- What do you think about the material?
2- Did the material you used help you learn the subject? How?
3- Did you have any difficulties while using the material? If your answer is yes, please explain at what points you have difficulties.
4- Did you need a guide during the use of the material?
5- How did you feel while using the material?
6- If you created the material, what would you like to change? Why?
7- Would you like the material to be used in science class and other lessons? Please explain.

Appendix 2: Codes Generated for The Material

Arduino UNO system established by researchers



Appendix 3: Questions That Can Be Used for Measurement and Evaluation Activities

1. If you compare the sizes of the sun, earth and moon with other sizes you know, what can you say about this?
2. Is there a relationship between the phases of the Moon and its position? If so, how would you explain this relationship?
3. Can you count the phases of the moon in order?
4. What is the difference between a new moon and a full moon? How would you explain?
5. How would you explain the difference between the phases of a gibbous moon and a crescent moon?

Appendix 4: People from The History of Science and Engineering

Galileo Galilei (1564 –1642)	400 years ago, he observed the sunspots he dropped on paper with his own invention, the telescope. In his observations at certain time intervals, he noticed that the sunspots shifted in the same direction. Thus, he reached the conclusion that "the Sun makes a rotation around its axis". Research after Galileo proved that the Sun rotates around its axis counter clockwise. This is the sign of the heliocentric system (MEB, 2021a).
Ibn Al-Haytham (965, 1040)	Ibn Al-Haytham, as Westerners call Alhazen, was an Arab mathematician, astronomer, and one of the important physicists of the Golden Age of Islam. He is also known as the "father of modern optics". Ibn Al-Haytham was the first to explain that light reflects off an object, then comes into his eyes, and thus the vision is realized. It was also the first to show, with evidence that imaging occurs in the brain rather than in the eyes. He designed a setup with the help of the lenses he used for his experiments. He was the first to conduct mathematical research on his famous experiment "The Dark Room". He rejected the view claimed by Aristotle and Ptolemy that the earth is the center of the universe. He said that the heliocentric system exists (MEB, 2021b).
Ali Qushji (1403-1474)	He was an important astronomer and mathematician who lived in the 15th century. He got the nickname "Birdman" because his father worked as a bird chef for Ulugh Beg. He took mathematics and astronomy lessons from important scientists, including Ulugh Beg, in Samarkand. Ulugh Beg appointed Ali Qushji as the director of the Samarkand Observatory. While working here, he made important contributions to the preparation of Ulugh Beg's famous work " Ulugh Beg's Star Catalog". He came to Istanbul upon the proposal of Mehmed the Conqueror. Ali Qushji, who saw the great interest of Mehmet here, gave lectures in the Hagia Sophia Madrasa (university in today's sense) and rearranged the program of the university. Ali Qushji; He wrote important works in the fields of arithmetic, astronomy and mathematical geography and was accepted as an authority in these fields for many years. In his work named “Er Risalet-i Fethiyye”, he focused on the positions and arrangement of the planets, the shape of the earth and climates, and the calculation of the diameter of the Moon and the Sun. He was the first to map the moon. (MEB, 2021c).