BUEFAD | **2021**, Volume **10**, Issue **1**, 51-68
Bartın University Journal of Faculty of Education
dergipark.org.tr/buefad
DOI: 10.14686/buefad.627796

Science for Students with Visual Impairment: An Analysis of Hands-on Activity

Seraceddin Levent Zorluğlu [a*], Aydın Kızılaslan [b], Mustafa Sözbilir [c]
a, Asst. Prof. Dr., Süleyman Demirel University (http://orcid.org/0000-0002-8958-0579) * seraceddinzorluoglu@sdu.edu.tr
b, Asst. Prof. Dr., Ağrı İbrahim Çeçen University (http://orcid.org/0000-0003-3033-9358)
c, Prof. Dr., Atatürk University (http://orcid.org/0000-0001-6334-9080)

Research Article	Received: **1.10.2019**	Revised: **15.10.2020**	Accepted: **22.10.2020**

Abstract

Science courses are considered to be one of the most difficult courses since they contain difficult and abstract concepts for the individual who needs special education. Because traditional science teaching is mostly based on visual teaching. However, an effective science education can be done by making instructional adaptations and taking into account the individual needs of the students. In this study, the science activities and materials prepared by taking into consideration the needs of the students with visual impairment using the case study of qualitative research methods were made. the study sample consisted eight students including three blind and five students with low vision. The Activity Evaluation Scale (AES) was used to collect data. At the end, activities and materials were evaluated by teacher and independent researchers. In order to ensure the reliability of the study, the videos which were recorded during the course separately analyzed by the researchers, the AES was filled and then the analyses of the researchers were compared. As a result, it was determined that the science activity and materials prepared for the students with visual impairment can be useful in teaching the concepts of heat conductor and heat insulator.

Keywords: Students with visual impairment, science education, science activities, science materials

Görme Yetersizliği Olan Öğrencilere Fen Eğitimi: Uygulamalı Etkinlik Analizi

Öz

Fen dersleri, çoğu özel eğitime gereksinim duyan birey için zor ve soyut kavramlar içerdiğinden en zor derslerden biri olarak kabul edilir. Çünkü geleneksel fen öğretimi çoğunlukla görsel öğretime dayandırılmıştır. Fakat öğretimsel uyarlamalar yapılarak ve öğrencilerin bireysel ihtiyaçları göz önünde bulundurularak etkili bir iyi fen öğretimi yapılabilir. Bu çalışmada nitel araştırma yöntemlerinden durum çalışması kullanılarak görme yetersizliği olan öğrencilerin ihtiyaçları dikkate alınarak hazırlanan fen etkinlik ve materyallerinin analizi yapılmıştır. Çalışma grubu üç görmeyen ve beş az gören öğrenciden oluşturmaktadır. Çalışmada veri toplama aracı olarak Etkinlik Değerlendirme Ölçeği (EDÖ) kullanılmıştır. Etkinlik sonunda dersi yürüten öğretmen ve bağımsız araştırmacılar tarafından etkinlik ve materyalleri değerlendirilmiştir. Çalışmanın güvenirliğinin sağlanması amacıyla ders esnasında kaydedilen videolar araştırmacılar tarafından ayrı ayrı izlenerek EDÖ doldurulmuş ve daha sonra araştırmacıların analizleri karşılaştırılmıştır. Sonuç olarak görme yetersizliği olan öğrenciler için hazırlanan fen etkinlik ve materyallerinin ısı iletkeni ve ısı yalıtkanı kavramlarının öğretiminde yararlı olabileceği tespit edilmiştir.

Anahtar kelimeler: Görme yetersizliği olan öğrenciler, fen eğitimi, fen etkinlikleri, fen materyalleri

To cite this article in APA Style:
Zorluoglu, S. L., Kizilaslan, A., & Sozbilir, M. (2021). Science for students with visual impairment: an analysis of hands-on activity. *Bartın University Journal of Faculty of Education, 10*(1), 51-68. https://doi.org/10.1016/buefad.627796

1 | Introduction

Visual impairment is a decreased ability to see to a degree that causes problems not fixable by usual means, such as glasses (Lusk & Corn, 2006). Students with disabilities face many difficulties in learning science subjects and concepts due to the disadvantages arising from disability (Isaacson, Supalo, Michaels & Roth, 2016). The abstract nature of the concepts in science lessons can prevent students' active participation in science activities (Kizilaslan, Zorluoglu & Sozbilir, 2020). Since these students feel insecure, they think that they will not be successful in science activities and will not be able to comprehend science subjects (Nepomuceno, Decker, Shaw, Boyes, Tantillo & Wedler, 2016). It is thought that these students will be able to learn, participate in activities and be interested in science by preparing activities considering their inadequacies for students with disabilities or by using sufficient amount of supplementary materials in teaching (Pence, Workman & Riecke, 2003). Teaching and students' learning can be facilitated by preparing tactile and audio materials for individuals with visual impairment, visual materials for individuals with hearing impairment, and materials that will teach individuals with intellectual disabilities at a simple level (Cavkaytar, 2013; Kızılaslan, Sözbilir & Zorluoğlu, 2019; Mete, Çapraz & Yıldırım, 2017).

Considering that 80% of learning is provided by the sense of vision (Ataman, 2012; Özkan, 2013), students with visual impairment are at a more disadvantage than other students with disabilities in terms of learning (Kızılaslan, Sözbilir & Zorluoğlu, 2019). For this reason, the sense of vision is very important in individuals' learning. Visual impairment occurs when individuals' vision is lower than normal vision (Cavkaytar & Diken 2012; Farnsworth & Luckner, 2008). In particular, academic and conceptual development, communication, life skills, and movement skills are negatively affected by visual impairment. In this sense, long processes of concept and skill development are required in these individuals, and organs other than the sense organ should be integrated into educational interventions in order to shorten this process (Lee & Templeton, 2008).

Students with visual impairment use their senses of hearing, touch, smell, and taste for the purpose of accessing information, apart from the sense of sight (Douglas & McLinden, 2005). Different learning situations and needs arise depending on the use of these students' senses (Pence, Workman & Riecke, 2003). The changing learning styles of these students depending on the existing visual impairment and visual impairment; It requires determining the educational needs of individuals, taking individual differences into consideration and restructuring the educational process. This situation varies according to the content of the courses, subject and concept density (Beard, Carpenter & Johnston, 2011).

Courses that require field knowledge are the most important lessons that students with visual impairment fall behind in the teaching process, both cognitively and educationally (Sapp & Hatlen, 2010). It is known that students with visual impairment cannot learn the subjects and concepts as effectively as other students in science lessons, especially due to the fact that they contain abstract concepts (Gray, 2009), and they need supporters that facilitate the student's learning (Zorluoğlu & Sözbilir, 2017).

In the learning process, individuals use cognitive processes effectively and structure information by constructing various patterns in the mind (Schreuer, Sachs, & Rosenblum, 2014). Information needs to be received by individuals, structured in the mind, shaped by individual and environmental thoughts and transferred to life (Cavkaytar & Diken 2012; Johnsen, 2001). In this context, science education makes sense with the fact that the information acquired in the process is applicable in daily life (Smith & Kelley, 2007). The purpose of science education in terms of acquiring applicable knowledge in daily life is to create an information society that is aware of science in this information age and to train individuals with the knowledge, skills, attitudes and behaviors required by the age (McGinnity, Seymour-Ford & Andries, 2004). Every student involved in the education process should acquire knowledge, skills and attitudes related to science courses (Fraser & Maguvhe, 2008). However, in science education for students with visual impairment, it is very important to bring different senses to the forefront in gaining the knowledge, skills and attitudes specified in the program and to integrate the materials that can use these sensory organs into teaching (Gyimah, Sugden & Pearson, 2009). Students who actively participate in the process and use supportive materials in teaching will learn more easily and there will be no misconceptions related to incorrect learning.

In the light of the data obtained from misconceptions made for different learning areas in the science course; even students with normal vision have misconceptions about the basic concepts in learning areas. (Mastropieri & Scruggs, 2010). In line with these results, students who have low vision or is blind cannot participate actively in the learning process. Also, teaching with incomplete or non-existent materials do not reflect the desired concept to be taught. It is thought that there may be more / different conceptual deficiencies (Mitchell, 2008). These conceptual deficiencies of the students with visual impairment who learn the information to be learned due to the lack of visual perception, the most important sensory sense, have been supported by some studies that can be solved by various teaching methods, techniques, strategies and designs (McLoughlin & Lewis, 2005).

When the studies on science teaching for the students with visual impairment were examined, it was found that most of them were hand-on studies. Linn and Thier (1975) made adaptations in the science program and materials to enable students with visual impairment to learn science courses in the inclusive classes. Lunney (1994) developed a computer software program for students with visual impairment to benefit from the chemistry laboratory effectively. Ratliff (1997) developed two experiments in the general chemistry laboratory that can be performed by students with visual impairment. Gupta and Singh (1998) developed experimental materials for students with visual impairment to conduct chemistry experiments with cheaper methods in the chemistry laboratory. Jonesi, Andre, Superfine and Taylor (2003) found that computer haptics interact with viruses on the microscope slide.. Beck-Winchatz and Ostro (2003) developed three-dimensional materials in the teaching of asteroid concept and taught the concept with real asteroids falling into our world. Supalo (2005) mentioned the teaching techniques that can be used by teachers to make chemistry courses more efficient for students with visual impairment, and mentioned techniques that can be developed to get more efficient grades and participate in classes. McGookin and Brewster (2007) developed a tactile tool and an application that allowed students with visual impairment to create bar graphs interactively. Neely (2007) developed laboratory materials in order to enable students with visual impairment to benefit from laboratory studies better. Poon and Ovadia (2008) developed tactile-based teaching materials for the effective processing of chemistry courses. Bromfield-Lee and Oliver-Hoyo (2009) developed laboratory activity to help students better understand the esterification of chemistry using their sense of smell. Boyd-Kimball (2012) developed adaptive tools and teaching techniques for blind students studying at the undergraduate level chemistry department. These tools include writing and balancing chemical reactions, unit conversion and concentration calculation, drawing Lewis's point structures, understanding and writing structural representations of molecules with three-dimensional models. Darrah (2013) examined the learning of the contents of the curriculum by using computer haptics and visual and auditory supporters to increase the access to mathematics and science.

In this study, the needs of the students with visual impairment were determined in order to teach science concept. Because of the fact that the concepts of heat conductor and heat insulator are abstract concepts, it is a known fact that students without visual impairment have difficulty in learning abstract science concepts and students with visual impairment have difficulty in learning abstract concepts even though they are supportive in learning abstract concepts. This study aims to teach the science concepts related with heat transfer topic

2 | METHOD

RESEARCH DESIGN

Case study was used in this study. Case studies aim to investigate a single person, group, event or community (McMillan & Schumacher, 2010). Typically, data is collected from various sources and using various methods (e.g., observations and interviews). Research can also continue for a long time, so processes and developments can be studied as they are (Creswell, 2007). As shown in Figure 1, the stages of the study can be listed as follows:

I. The needs of the students with visual impairment to learn the science course gains were determined

II. Taking into account the information obtained in the first step, activities and materials for the concepts of heat conductor and heat insulator have been developed

III. The activities and materials developed in the second stage were applied to the students in the classroom environment.

IV. The contribution of activities and materials to learning related concepts is examined.

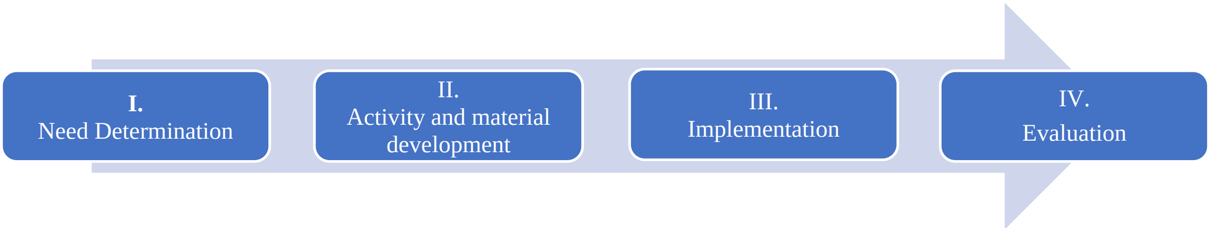

Figure 1. *Stages of the Study*

In the first stage, conceptual learning difficulties related to the concepts of heat, heat conductor and heat insulator were determined. For this purpose, in-class observations video camera recording and semi-structured interviews was used. In the second stage, activity, activity material and course module were developed in line with these identified needs (Appendix 1). For this purpose, firstly the individual needs of the students due to visual impairment were classified. For the students with low vision and blind students, the characteristics of the materials (the size of the material, - the size of the security, etc.) are designed for the students with low vision. The documents prepared for the students with low vision were in Century Gothic font and at least 18 font size. According to the research Century Gothic was identified as the best readable font by students with visual impairment (Çakmak, Karakoç, Şafak & Kan, 2014). The principles of module, activity and activity materials are as follows (Bailey & Daniel, 1993; Brigham, Scruggs & Mastropieri, 2011; Çakmak, Karakoç, Şafak & Kan, 2014; Sözbilir, Zorluoğlu & Kızılaslan, 2019; Karakoç, 2016; Teke & Sözbilir, 2019):

1. Pay attention to the fact that the prepared materials address multiple senses.

2. The articles on the materials prepared for the students with low vision should be at least 18 pt.

3. Teaching materials and information for the purpose of the contrast to be created on the document should be in a contrast.

4. Instructional material should be formed from substances that stimulate the sense of tactile and reveal similarities and differences.

5. Ratio-scale, integrity, accent and harmony adjustment should be provided as a whole. In other words, the harmony of an object with the other object and its relation with the whole should be given importance.

6. The prepared materials should be appropriate to the students' characteristics (age, intelligence and order of past experiences).

7. The meaning of material makes learning easier. For this purpose, the material must be exactly matched with the subject or concept intended for teaching.

8. Emphasis should be placed on the acquisition of cognitive knowledge as well as affective and psychomotor skills.

9. Heterogeneous groups should be formed according to the students' vision level in material design integrated with activity.

The module booklets prepared for the course are presented to two experts in science education and special education. The experts have examined the guidelines in terms of scope, structure, language and appearance. These experts specifically examine scientific conceptual understandings of students with visual impairments. Their works include exploring students' with visual impairments conceptual understanding of physical and environmental science through inquiry-based education. The module booklets were revised in line with the opinions taken from the experts and the teacher.

Study group

The study group consisted of a total of eight students, three of them were blind and others were low vision. Three of the students are girls while five of them are boys. The age range is between 12 and 15 years. Two students receive access support for independent movement, while six students do not need access support for independent movement. Two students need an auxiliary material to read, while six do not need any supplementary material for reading (Table 1).

Table 1. Sample of the Study

Students	Gender	Age	Visual acuity	Mobility training	Use reading aids
S_1	Female	13	Blind	Receive training	No
S_2	Female	15	Low vision	No training	Yes
S_3	Female	14	Low vision	No training	Yes
S_4	Male	14	Low vision	No training	No
S_5	Male	13	Low vision	No training	No
S_6	Male	12	Low vision	No training	No
S_7	Male	13	Blind	Receive training	No
S_8	Male	15	Blind	No training	No

Data collection tools

Data were collected using the Activity Evaluation Scale (AES) (Table 2). In the first stage, evaluation criteria were determined by taking the opinions of three science education and one special education expert. In the evaluation criteria, the general analysis of the activity and the contribution of the activity to the teaching of the subject and concept were examined. The activities and materials prepared for the students with visual impairment were evaluated by the teachers and independent researchers conducting the course. The graded system in the scale is 'strongly agree' (4), 'agree' (3), 'neutral' (2), 'disagree' (1), and 'strongly disagree' (0). Necessary corrections have been made in the evaluation criteria considering the expert opinions. In order to ensure the reliability of the study, the videos recorded during the course were watched by independent researchers separately and they were asked to complete the AES form. As a result of independent analyses, the compliance percentage was determined as 77.7%.

Table 2. Activity Evaluation Scale (AES)

Performance Criteria	Ratings					Score
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
The activity was appropriate to the level of interest and understanding						
The activity was clearly and logically organized						
The instruction materials were practical						
The activity duration was appropriate						
The activity met the identified needs						
The activity was easy to understand						
The activity was relevant to students' educational needs						
The activity was well-structured and organized						
Over-all quality of the activity met students' expectations						
Total score (Researcher)						
Total score (Teacher)						
Mean score						

Data Analysis

Descriptive data analysis method was used in the study. In descriptive analysis, data may not be interpreted according to previously determined themes. In a descriptive analysis, where data are presented with a flexible approach, direct quotations are frequently used to reflect the views of the individuals interviewed or observed (Hill, Thompson, & Williams, 1997). During the course module, the courses were recorded with the help of video camera. In order to ensure validity and reliability, the courses were recorded in the video camera and the situations considered as necessary were followed again and compared with the first observations.

3 | Findings

In this section, the course module, science activity and activity materials prepared for the purpose of teaching the heat, heat conduction and heat insulation concepts will be evaluated. Before proceeding to the findings, a detailed analysis of the course will be carried out (Figure 2 below).

The course is student-centered. At the beginning of the course, the teacher presented the materials to be used and asked the students to examine the materials. The teacher asked the question what is in his hand to check if the materials are understood by the students. After receiving the necessary answers, the activity document prepared by taking into account the inadequacies of the students were distributed to the students and the students were asked to read them individually. The talking thermometer was used to perform the activity individually. During the activity, the teacher asked questions about the activity - so that the students could understand what they were doing and to make sense of the information they obtained. At the end of the activity, the students were asked about the concepts of heat conductor and heat insulator by asking the end of the activity to be structured by the students. At the end of the course, the information sheets prepared by taking into consideration the inadequacies of the students to consolidate the information they have learned were distributed.

<u>Beginning of the course:</u>

Teacher: Now I'm going to give you the materials of the activity we are going to do today and you will examine them.

The teacher gives the wooden spoon, iron spoon, talking thermometer and glass bowl assembly to the students and asks the students to examine these materials.

Teacher: Yesss. You think this is what?

S8: This is the spoon. It's like iron.

Teacher: So what is this S6?

S6: My teacher is a wooden spoon. Light already.

Teacher: If everyone understands what is in front of them, you will distribute the activity sheets and try to understand it because you will make the activity.

The teacher distributes and prepares the papers of activity which are prepared by taking into account the inadequacies of each student. Then he asks the following questions to test if the students understand what they are reading and gets an answer:

Teacher: What will we find at the activity?

S1: Heat conduction of the spoon

Teacher: we'll find out which spoon conveys less heat at this activity.

Teacher: What are the necessary materials?

S3: Two pieces of iron spoon, wooden spoon, bowl, hot water, cold water, speaking thermometer.

<u>Teaching of course:</u>

Teacher: Now everyone should touch the bowl without touching too much. What do you feel?

S4: Hot

Teacher: Now measure the temperature of both the wooden spoon and the iron spoon with your hand and the thermometer.

Teacher: Now what do you expect to have on your spoons?

S7: Can I say it? We expect the spoon to be hotter.

Students measure the temperature of the spoons and wait for a certain time to touch the spoons and measure the temperature of the spoons with the thermometer again.

Teacher: Which is hotter which is colder? Yeah, S2, touch me which is hotter and which is colder?
S2: The following is hotter (iron spoon), it is more cold (wooden spoon)
Teacher: how were the spoons you put in this bowl?
Students were warm.
Teacher: How were the spoons after putting hot water in it?
S5: iron spoon was warmer than the wooden spoon was warm.
Teacher: How did you think the iron spoon became hot here?
S6: gave hot water temperature
Teacher: What happened when it was hot?
S1: received heat from water.
Teacher: what we aimed from the outset was to determine the heat conductor and heat insulator. Which of these materials do you think is the heat conductor which is the heat insulator?
S5: The thing is iron is warmer than the hot board.
S4: Iron conveyed heat then the board did not pass fully.
Teacher: whichever heat conductor is the heat insulator?
S4: Iron is the conductor of heat conductor.
Teacher: we can say on the board as heat insulator.
Students: Yesssss.
The teacher summarizes the activity and defines the concepts of heat conductor and heat insulator and distributes the leaflets prepared by taking into consideration the inadequacies for the students to repeat.

Figure 2. *Observations on the Implementation of the Module in the Classroom*

It is seen that the activity meets the needs in many areas in the analysis of the effectiveness according to the evaluation areas, experts and teacher evaluation (Table 4). According to Table 4, one of the expert researchers gave three points to the attractiveness of the event and the other expert researcher and teacher gave it full score. All evaluators stated that the activity was organized in a logical way and that the materials were simple and practical and the duration of the activity was appropriate. Similarly, experts and teachers stated that the activity met the learning needs, was easy to understand, allowed for collaborative work, activity steps were well structured and the activity met the expectations.

Table 4. Analysis of the Activity According to Evaluation Field

Activity Evaluation Field	Teacher Assessment	Researcher Assessment	Researcher Assessment	Total Score	% performance
The activity was appropriate to the level of interest and understanding	4	4	3	11	92
The activity was clearly and logically organized	4	4	4	12	100
The instruction materials were practical	4	4	4	12	100
The activity duration was appropriate	4	4	4	12	100
The activity met the identified needs	4	4	4	12	100
The activity was easy to understand	4	4	4	12	100
The activity was relevant to students' educational needs	4	4	4	12	100
The activity was well-structured and organized	4	4	4	12	100
Over-all quality of the activity met students' expectations	4	4	4	12	100

4 | Discussion & Conclusion

Students with visual impairment use their other senses at different degrees and frequency depending on the insufficiency in their vision. By taking into consideration the individual needs of the students, it is possible to facilitate the access to scientific knowledge to individuals with visual impairment by means of different senses in the teaching process (Holahan, McFarland & Piccillo, 1994). In this study, an activity design and activity materials related to this activity were designed so that students with visual impairment can better understand the subject of heat transfer. These activity materials consist of student activity sheet and teacher information package. These activity materials were brought to the forefront of the students' different senses and the students were included in the concept learning process related to the subject

A course package was prepared for the teachers and students to carry out the activity process in a clear, comprehensible and logical framework. As included in the appendix, it was provided to enable the teacher to carry out the course in a planned process by including information on how to include the total blind and low vision students in the course information package and what adaptations they should make in terms of security and the questions to be asked during the activity process (Kızılaslan, 2019). In our country, the implementation of disaggregated schools, in which all individuals in need of special education cannot participate in the integration, are continuing. Specialist teachers in these schools may be inexperienced due to lack of specialization in the branch of special education (Kızılaslan, Sözbilir & Zorluoğlu, 2019). Therefore, elaboration of the teaching process in the course information package increases the self-confidence of the teachers and contributes to the active participation of the students. Activity materials were chosen from daily life products, this has enabled the students to be more easily involved, especially in total blind students. Especially for the total blind student using the sense of touch, the easy perception of daily living materials makes it easier to learn and save time (Kumar, Ramasamy &

Stefanich, 2001). The activity was completed in the determined time and care was taken not to step out of the curriculum. As can be seen in the activity analysis, students were brainstormed during the activity process and students were asked questions for evaluation by the end of the activity. It can therefore be concluded that the activity met the learning needs of students. The fact that the activity was chosen from the daily living materials and the activity process was structured for both the teacher and the student facilitated the understanding of the activity. The fact that the message to be given is simple and does not allow sensory confusion is one of the factors facilitating learning especially in students with visual impairment (Dickerson, Smith & Moore, 1997). The fact that the activity consisted of two heterogeneous groups led the students to carry out the activity process in cooperation. Weisberger (1995) states that very structured inquiry and cooperative learning for children with visual impairment is the most effective method in science teaching. Students with low academic success learn in a collaborative environment better than their gifted peers (Kapperman, Heinze & Sticken, 2010; Kizilaslan, Zorluoglu & Sozbilir, 2020). In an inclusive class, collaborative learning among students with different learning abilities and learning needs has proved to be effective in promoting academic achievement, promoting positive attitudes towards the subject and improving social interaction between students (Heward, 2006; Zorluoglu, Sözbilir & Kızılaslan, 2016).

Suggestions

Students with visual impairments use their other senses at different degrees and frequency depending on the insufficient vision. By considering the individual needs of students, it can be facilitated for individuals who are affected by visual impairment to access scientific information by emphasizing different senses in the education-teaching process.

Standard curriculum is applied in schools in Turkey, individual needs or special needs of students are often ignored. Therefore, there is a need for adaptations and improvements in science teaching for individuals with visual impairment. In this study, the teaching of the concept of heat transfer with differentiated teaching materials and activities was done to the students with visual impairment and the efficiency of these activities and materials were examined. The prepared activities and materials are interesting, simple and practical, meet the student needs, are easy to understand by the students, the application time is sufficient for the students with visual impairment, they meet the expectations of the students; It was determined by the experts that the students carried out the activities with peer solidarity, the steps of the activities were structured in such a way that the students performed the activity themselves, and they were organized in a clear and logical way. Considering the Activity Evaluation Scale included in the study, the development of activities for students with visual impairment can be ensured that these students actively participate in the activities and that meaningful learning takes place as a result of teaching.

It was observed that the prepared activities and materials are interesting, simple and practical, meet the student needs, are easy to understand by the students, the application time is sufficient for the students with visual impairment, they meet the expectations of the students; It was determined by the experts that the students performed the activities with peer solidarity, the activity steps were structured in such a way that the students perform the activity themselves, and they were organized in a clear and logical way.

As a result, various adaptations and improvements in effective science teaching in line with the needs of individuals with visual impairments can be economically costly. For this reason, schools and teachers should be provided with budget support in terms of providing tools and materials support considering the individual differences of the students.

Recommendations for Teachers

As a result of interviews and observations with the students, it was determined that students with visual impairment did not learn much of the concept of 'Matter and Heat' on conceptual level. The reasons for this are to explain the concepts mainly by verbal means, the lack of printed documents in the hands of the students and the lack of tactile materials to facilitate the teaching of the concept.

The concepts of heat and heat insulation are abstract concepts which are very difficult to learn. The concept of heat insulation is understood by very few students. Basic misconceptions in the literature are listed below.

- Metals absorb cold, amounts and absorb.
- Conductors conduct heat more slowly than insulators.
- Insulators transmit heat very quickly, the heat is immediately separated from the insulators and therefore never heat up.
- Insulators absorb heat. Woolen heat the substances they are in contact with.
- Metal does not transmit heat well.
- Porcelain does not transmit heat at all.
- When we touch the metal at room temperature and touch the metal, we feel cold because our hands are hot.

Acknowledgement

This study was funded by the Scientific and Technological Research Council of Turkey by Grant #114K725. The authors would like to thank the teachers and students who voluntarily participated in this study.

References

American Foundation for the Blind. (2015). Low vision and legal blindness terms and descriptions. retrieved from http://www.visionaware.org/info/your-eye-condition/eye-health/low-vision/low-vision terms-and-descriptions/1235

Avramidis, E., & Norwich, B. (2010). Teachers' attitudes towards integration/inclusion: A review of literature. *European Journal of Special Needs Education, 17*(2), 129–147.

Bailey, B.R., ve Daniel, N. (1993). Providing O&M services to children and youth with severe multiple disabilities. *RE:view: Rehabilitation and Education for Blindness and Visual Impairment*, *25*(2), 57–64.

Bardin, J. A., & Lewis, S. (2008). A survey of the academic engagement of students with visual impairment general education classes. *Journal of Visual Impairment & Blindness, 102*(8), 472-483.

Beard, L. A., Carpenter, L. B., & Johnston, L. B. (2011). *Assistive technology: Access for all students* (2nd ed.). Upper Saddle River, NJ: Pearson Education.

Beck-Winchatz, B., & Ostro, S. J. (2003). Using asteroid scale models in space science education for blind and visually impaired students. *Astronomy Education Review*, *2*(2), 118-126.

Borg, J., Lindstrom, A., & Larsson, S. (2009). Assistive technology in developing countries: National and international responsibilities to implement the convention on the rights of persons with disabilities. *Lancet*, *374*(28), 1863-1865

Boyd-Kimball, D. (2012). Adaptive instructional aids for teaching a blind student in a nonmajors college chemistry course, *Journal of Chemistry Education*, *89*, 1395-1399.

Brigham, F.J., Scruggs, T.E., ve Mastropieri, M.A. (2011). Science education and students with learning disabilities. Learning Disabilities Research & Practice, 26(4), 223–232.

Bromfield-Lee, D.C., & Oliver-Hoyo, M.T. (2009). An esterification kinetics experiment that relies on the sense of smell. *Journal of Chemistry Education*, *86*(1), 82-84.

Cavkaytar, A. (2013). Özel eğitime gereksinim duyan çocuklar ve özel eğitim, İ. H. Diken (Ed.). *Özel Eğitime Gereksinimi Olan Öğrenciler ve Özel Eğitim* içinde. Ankara: Pegem Yayıncılık. [Cavkaytar, A. (2013). Children who need special education and special education, İ. H. Diken (Ed.). Students in need of special education and special education. Ankara: Pegem Publishing.]

Cavkaytar, A., & Diken, İ. H. (2012). *Özel eğitim: Özel eğitim ve özel eğitim gerektirenler* (1.baskı). Ankara: Vize Basın Yayın. [Cavkaytar, A., & Diken, İ. H. (2012). Special education: Those who require special education and special education (1st edition). Ankara: Vize Publishing.]

Creswell, J.W. (2007). *Qualitative inquiry and research design: Choosing among five traditions* (Second edition). London: Sage.

Çakmak, S., Karakoç, T., Şafak, P., & Kan, A. (2014). Identifying the reading speed of low vision student's at elementary level. *International Journal in IT & Engineering*, *2*(10), 38-48.

Darrah, M. A. (2013). Computer haptics: A new way of increasing access and understanding of math and science for students who are blind and visually impaired. *Journal of Blindness Innovation and Research*, *3*(2), 3-47.

Dickerson, L.R., Smith, P.B. & Moore, J.E., (1997). An overview of blindness and visual impairment', in Moore J.E., Graves W.H. & Patterson J.B. (eds.), *Foundations of rehabilitation counseling with persons who are blind or visually impaired*, pp. 1–24, American Foundation for the Blind, New York.

Douglas, G., & McLinden, M. (2005). Visual Impairment, in A. Lewis & B. Norwich (eds). *Special Teaching for Special Children? Pedagogies for Inclusion*, pp. 26– 40. Maidenhead, UK: Open University Press

Farnsworth, C. R., & Luckner, J. L. (2008). The impact of assistive technology on curriculum accommodation for a Braille-reading student. *RE:view: Rehabilitation and Education for Blindness and Visual Impairment*, *39*(4), 171-187.

Fraser, W. & Maguvhe, M. (2008). *Teaching Life Sciences to Blind and Visually Impaired learners*. South Africa. University of Pretoria.

Gray, C. (2009). A qualitatively different experience: mainstreaming pupils with a visual impairment in Northern Ireland. *European Journal of Special Needs Education*, *24*(2), 169-182. doi:10.1080/08856250902793644.

Gyimah, E., Sugden, D., & Pearson, S. (2009). Inclusion of children with special educational needs in mainstream schools in Ghana: influence of teachers' and children's characteristics. *International Journal of Inclusive Education*, *13*(8), 784-804

Johnsen, B. H. (2001). Curriculum for the plurality of individual learning needs: Some thought concerning practical innovation towards an inclusive class and school. In B.H Johnsen and M.D. Skijorten, (Eds), *Education-Special Needs Education: an introduction*. Oslo. Unpub.

Jones, M. G., Andre, T., Superfine, R., & Taylor, R. (2003). Learning at the nanoscale: The impact of students' use of remote microscopy on concepts of viruses, scale, and microscopy. *Journal of Research in Science Teaching*, *40*(3), 303-322.

Heward, W.L. (2006). *Exceptional Children: An introduction to special education* (8th ed.). New Jersey: Pearson Merrill Prentice Hall.

Hill, C. E., Thompson, B. J., & Williams, E. N. (1997). A guide to conducting consensual qualitative research. *The Counseling Psychologist*, *25*, 517– 572.

Isaacson, M. D., Supalo, C., Michaels, M., & Roth, A. (2016). An Examination of Accessible Hands-on Science Learning Experiences, Self-Confidence in One's Capacity to Function in the Sciences, and Motivation and Interest in Scientific Studies and Careers. *Journal of Science Education for Students with Disabilities*, *19*(1), 68-75.

Kapperman, G., Heinze, T., & Sticken, J. (2010). Modifying and designing instruction: Mathematics. In. A.J. Koenig & M.C. Holbrook (eds.) *Foundation of education (2nd ed.). Volume II: Instructional strategies for teaching children and youths with visual impairment*. pp.370-399. New York: AFB Press.

Karakoç, T. (2016). *Görme yetersizliği olan öğrencilerin araştırmaya dayalı öğrenme yaklaşımı modellerinden rehberli keşfetme modelinin deneysel işlemleri kazanmalarına, akademik başarılarına ve fen bilgisine ait tutumlarına etkisi*. (Yayımlanmamış Doktora Tezi). Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.[Karakoc, T. (2016). *The effect of guided discovery model, one of the research-based learning approach models, on the achievement of experimental procedures, academic achievement and attitudes towards science of visually impaired students.* Unpublished PhD Thesis. Gazi University, Institute of Educational Sciences, Ankara.]

Keller, E. (2005). *Strategies for teaching learners with visual impairments*. Retrieved from http://www.as.wvu.edu/vision.htm.6 July 2014.

Kelly, S. M., & Smith, D. W. (2011). The impact of assistive technology on the educational performance of students with visual impairments: A synthesis of the research. *Journal of Visual Impairment and Blindness*, *105*(2), 73-83.

Kızılaslan, A. (2019). Linking Theory to Practice Science for Students with Visual Impairment. *Science Education International*, *30*(1), 56–64.

Kızılaslan, A., Sözbilir, M., & Zorluoğlu, S. L. (2019). Making science accessible to students with visual ımpairments: ınsulation-materials investigation. *Journal of Chemical Education*, *2019*(96), 1383-1388.

Kizilaslan, A., Zorluoglu, S.L., & Sozbilir, M. (2020). Improve learning with hands-on classroom activities: science instruction for students with visual impairments, *European Journal of Special Needs Education*, DOI: 10.1080/08856257.2020.1732110

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), 1–4.

Lee, H., & Templeton, R. (2008). Ensuring equal access to technology: Providing assistive technology for students with disabilities. *Theory Into Practice*, *47*(3), 212-219.

Linn, M. C., & Thier, H. D. (1975). Adapting science material for the blind (ASMB): Expectation for student outcomes. *Science Education*, *59*(2), 237-246.

Lunney, D. (1994). Development of a data acquisition and data analysis system for visually impaired chemistry students. *Journal of Chemistry Education*, *71*(4), 308

Lusk, K. E., & Corn, A. L. (2006). Learning and using print and braille:A study of dual-media learners: Part 1. *Journal of Visual Impairment and Blindness*, *100*, 606–619

Mastropieri, M.A. & Scruggs, T.E. (2010). *The Inclusive Classroom: Strategies for Effective differentiated Instruction*. New Jersey: Upper Saddle River.

McGinnity, B.L., Seymour-Ford, J. & Andries, K.J. (2004). *Founders. Perkins History Museum, Watertown*, MA: Perkins School for the Blind.

McGookin, D. K., & Brewster, S. A. (2007). Graph builder: Constructing non-visual visualizations. In Bryan-Kinns, N., Blandford, A., Curzon, P. and Nigay, L. (Eds.) *People and computers XX – Engage: proceedings of HCI 2006* (pp. 263-278). London: Springer.

McLoughlin, J.A. & Lewis, R.B. (2005). *Assessing students with special needs* (6th Ed). New Jersey: Pearson Education, Inc.

McMillan, J.H. & Schumacher, S. (2010). *Research in education: Evidence-based inquiry* (7th ed.). New York, NY: Pearson.

Mete, P, Çapraz, C., & Yıldırım, A. (2017). Science education for intellectual disabled students. *Journal of Graduate School of Social Sciences*, *21*(1), 289-304.

Mitchell, D. (2008).What Really Works in special and ınclusive education: using evidence based teaching strategies. London: Routledge: Taylor & Francis Group.

Nepomuceno, G. M., Decker, D. M., Shaw, J. D., Boyes, L., Tantillo, D. J., & Wedler, H. B. (2016). The value of safety and practicality: Recommendations for training disabled students in the sciences with a focus on blind and visually impaired students in chemistry laboratories. *Journal of Chemical Health and Safety*, *23*(1), 5-11.

Pence, L. E., Workman, H. J., & Riecke, P. (2003). Effective laboratory experiences for students with disabilities: The role of a student laboratory assistant. *Journal of Chemical Education*, *80*(3), 295.

Poon, T. & Ovadia, R. (2008). Using tactile learning aids for students with visual ımpairments in a first-semester organic chemistry course. *Journal of Chemistry Education*, *85*(2), 240-242.

Quek, F., & McNeill, D. (2006). Embodiment awareness, mathematics discourse, and the blind. *Annals of the New York Academy of Sciences*, *1093*, 266–279.

Sapp, W., and Hatlen, P. (2010). The expanded core curriculum: where we have been, where we are going, and how we can get there. *Journal of Visual Impairment & Blindness,104*(6), 338.

Sarah, J. Neal, A. & Cathy, D. (2005). *What successful teachers do in inclusive classrooms*? United Kingdom: Corwin Press.

Schreuer, N., Sachs, D. & Rosenblum, S. (2014). Participation in leisure activities: differences between children with and without physical disabilities. *Research in Developmental Disabilities*, *35*(1), 223-233.

Simon, C., Echeita, G., Scandoval, M., & Lopez, M., (2010). The inclusion education process of students with visual impairments in Spain: An analysis from the perspective of organizations. *Journal of Visual Impairment and Blindness*, *104*(9), 565-570.

Smith, D.W. & Kelley, P. (2007). A survey of assistive technology and teacher preparation programs for individuals with visual impairments. *Journal of Visual Impairment & Blindness*, *101*(7), 429-433.

Smith, E.C.T., Polloway, E.A., Patton, J.R., & Dowdy C.A. (2012).*Teaching students with special needs in Inclusive Settings.* New Jersy, Prentice Hall.

Sözbilir, M., Zorluoğlu, S. L., & Kızılaslan, A. (2019). The effect of activities prepared for students with visual impairment on the scientific process skills: Matter and heat. *Cumhuriyet International Journal of Education*, *8*(1), 172-192.

Supalo, C. (2005). Techniques to enhance instructors' teaching effectiveness with chemistry students who are blind or visually impaired. *Journal of Chemistry Education*, *82*(10), 1513-1518.

Ratliff, J.L. (1997). Chemistry for the visually impaired. *Journal of Chemistry Education*, *76*(4), 710-711.

Teke, D., & Sözbilir, M. (2019). Teaching energy in living systems to a blind student in an inclusive classroom environment. *Chemistry Education Research and Practice*, DOI: https://doi.org/10.1039/C9RP00002J

Zorluoğlu, S. L., & Sözbilir, M. (2017). Learning support needs of visually impaired students. *Trakya Journal of Education*, *7*(2), 659-682.

Zorluoğlu, S. L., Sözbilir, M., & Kızılaslan, A. (2016). Teacher educators' views on scientific literacy of visually impaired students. *Cukurova University Faculty of Education Journal*, *45*(2), 209–242.

APPENDIX

Subject	Matter and Heat
Concepts	Heat conductor, heat insulation, heat insulation, heat insulation materials
Objectives	6.6.1.1. Classify substances in terms of heat conduction 6.6.1.2. [Conceptual knowledge / understanding] 6.6.1.3. Discusses the importance of thermal insulation in buildings in terms of family and country economy and effective use of resources 6.6.1.4. [Conceptual knowledge / Analysis]. 6.6.1.5. Determine the selection criteria of thermal insulation materials used in buildings 6.6.1.6. [Conceptual knowledge / Comprehension]. 6.6.1.7. Develops alternative thermal insulation materials 6.6.1.8. [Conceptual knowledge / Creation].
Science process skills	Observing, measuring, classifying, saving data, establishing hypothesis, using data and model, changing and controlling variables, conducting experiments.
Life skills	Analytical thinking, decision making, creativity, communication and teamwork.
Affective skills	Positive attitude development, pleasure to learn, willingness, value of the contribution of science, feeling individual and social responsibility.
SSTE	Relationship between science and technology, social contribution of science, science and career awareness

Course Information Package

Subject: Heat conductor and heat insulator

Objectives: 6.6.1.1 Classifies substances for heat conduction.
Duration: 40+40

Application Warnings

- Inform students about the materials to be used in Worksheet 1 and 2.
- For the activity in Worksheet 1 and 2, divide the students into two groups to form a heterogeneous structure in terms of visual impairment.
- Carry out safety warnings regarding the dangers of hot water. Make sure that the bowls and glasses are fixed with silicone on a wooden floor for activity in work sheets 1 and 2.
- For those who have never seen, it is reminded that the titles in TGA paper should be spoken verbally and written with tablet.

Process of the Lesson

- At the end of this activity, inform students about the concept of heat conductor and heat insulator.
- Start with the activity with Work Sheet 1.
- Use the question-answer and brainstorm technique to continue with the following questions about the relationship of matter to heat.

✓ Which of the spoons did you get the most?
✓ Which of the spoons warmed your hand most?
✓ While the wooden spoon did not heat your hand too much, the iron spoon warmed your hand further. What is the reason of this?
✓ What is the relationship between the measured temperatures of the spoons and the ones you feel when you touch them? What do you think is the reason for this relationship?
✓ What kind of spoons should we use when cooking? Why is that?
✓ Why should we use a wooden spoon when cooking?

- Answer the questions in the “The result of the activity” with your students.

✓ What do you think is heat insulator?
✓ What does the heat conductor mean?
✓ Is a heat conductor or a heat conductor if a substance delivers heat very well?

- Ask students to disseminate and read the Information Sheet 1 on the concepts learned in the conclusion section of the activity. Then repeat the concepts and make explanations if necessary.
- Ask students to give examples of heat conductors and heat insulators in their environment.

At the end of the course, ask students to define the concepts in this lesson

Activity Worksheet

Activity: Which spoon conveys less heat?

Necessary materials:

- ✓ 2 pieces of iron spoon
- ✓ 2 wooden spoons
- ✓ 2 bowls
- ✓ Warm Water
- ✓ Cold Water
- ✓ Talking thermometer

Let's Do the Activity

1. Measure the temperature of the spoons with a thermometer and touch them separately. Let's record our observations.

2. Let's use the illustrated bowl assembly and add hot water to one of the bowls and ice water to another.

3. Then put one iron and wooden spoon in each bowl.

After five minutes, measure the temperature of the spoons in each bowl with a thermometer and touch them separately. Let's write what we're observing.

Spoon Type	Pre-Experiment		Post-Experiment	
	Temperature	Touch Feeling	Temperature	Touch Feeling
Iron				
Wood				

Let's answer the following questions

1. Which one of your spoons did you have a cold?
2. Which of the spoons warmed your hand?
3. Sort your hands from the warmest to the highest heat.
4. Sort the spoons from the lowest to the highest.

Information Sheet

Each substance does not transmit the same heat. Substances are called heat conductors and heat insulators according to their heat conduction. Heat conducting material that does not interfere with heat exchange or conducts heat well. Metals such as gold, silver, copper, aluminum, iron and steel are examples of materials that conduct heat. Materials that do not conduct heat well are called heat insulating materials. Examples of heat insulating materials are plastics, wood, straw, leather, fibers and cotton.