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Research Article

Are we aware of the needs of students with visual impairment? A study on challenges and instructional needs in science lessons

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This paper is twofold. First, it aimed to reveal the challenges experienced by middle school students with visual impairment in science lessons. Second, it attempted to determine their instructional needs. In the current study, in which 13 students studying in a middle school for the visually impaired and 10 teachers working in the same school were the participants, the case study method was adopted. Interviews and observations were used as two separate data collection tools. While interviews were conducted with both students and teachers, science lessons were also evaluated through a structured observation form. Interviews with students showed that the majority of their needs were related to school equipment and tools as well as ways to acquire knowledge. Teachers highlighted designing teaching environments and providing assessment and evaluation as their needs in interviews. Furthermore, observations showed that teachers prefer teacher-centered approaches and use inappropriate materials for their students. Finally, the study discussed the implications for future researchers.

Keywords: Students with visual impairment, science lessons, challenges, difficulties, instructional needs

1. Introduction

People with special needs have some basic differences from their peers in terms of their physical, mental, emotional, and social characteristics as well as their educational requirements (Adibsereshki & Salehpour, 2014). According to the World Health Organization [WHO] (2023), the number of individuals with visual impairment among individuals with special needs is approximately 1 billion. The main conditions that cause distance vision impairment or blindness among these individuals are: cataract (94 million), refractive errors (88.4 million), age-related macular degeneration (8 million), glaucoma (eye pressure) (7.7 million), and diabetic retinopathy (3.9 million). In addition, the main condition that causes near vision impairment is presbyopia, which affects 826 million people (WHO, 2023). As in the world, the number of individuals with visual impairment is quite high in our country. According to the latest research data of TurkStat, individuals with visual impairment constitute 1.4% of the Turkish population (General Directorate of Disabled and Elderly Services [GDDES], 2021). Due to the large number, studies on students with visual impairment are of utmost importance.

Blindness is most generally defined as the loss or absence of perception of visual stimuli (Chiracu & Buica-Belciu, 2023). In another definition, Şafak (2018) defines visual impairment as "the inability of the eye to perform its visual function as a result of damage to the structure of the eye for various reasons" (p. 28). Accordingly, low vision is defined as visual acuity between 20/70 and 20/400, with the best possible correction, or a visual field of 20 or less than 20 degrees. Blindness is defined as a visual acuity less than 20/400, with the best correction, or a visual field less than 10 degrees. The denominator of the visual acuity ratio of 20/200 represents how many feet of distance a person with normal vision can see, while the numerator represents how many feet of distance an individual with visual impairment can see (Şafak, 2018). In addition to this legal definition, it is necessary to know the educational definition, because the legal definition does not provide educators with sufficient information about the educational needs of individuals with visual impairment. In this respect, according to the educational definition, individuals who need tactile (relief) writing, i.e. Braille alphabet and auditory materials to meet their educational needs are called blind, whereas individuals who can read normal writing using a magnifying glass or large print are called low vision (Aydın O'Dwyer & Akça Bayar, 2017). The Turkish Special Education Services Regulation also defines an individual with visual impairment as "an individual who needs special education and support education services due to partial or total loss of vision" (Special Education Services Regulation, 2018).

Considering that vision is vital in learning, students with visual impairment who have low vision or who are completely blind have more limited access to information in educational environments compared to their peers with normal development (Gordon, 2004; Güler, 2023; Palan, 2021; Vlachou & Papananou 2015; Zebehazy et al., 2012). Science and mathematics lessons, especially the abstract nature and the abundance of visual stimuli, make it more difficult for students with visual impairments to learn subjects and concepts than their peers with normal vision (Opie, 2018; Palan, 2021; Rule et al., 2011; Sahin & Yorek, 2009; Ürey & Güler, 2018;). Almost all science lessons involve visual representations like pictures, figures, formulas, and graphs, so little is known about how students with visual impairments access such visual materials (Jones et al., 2006). Due to limited access to visual stimuli, students with visual impairments have lower academic achievement expectations than their peers (Gordon, 2004; Moreland, 2015). A number of factors are thought to cause to low academic achievement expectation, including inadequate transfer of scientific visual representations to students, difficulties making sense of two-dimensional representations of three-dimensional concepts, and the need to interpret graphics in order to explain information from diagrams (Cryer et al., 2013; Rosenblum et al., 2019; Rule et al., 2011).

In spite of having similar cognitive abilities and competencies as their peers, students with visual impairments seem to have difficulty teaching science topics and concepts (Kumar et al., 2001). Due to the aforementioned limitations, they cannot access non-visual teaching materials and teaching methods, or they cannot use these materials professionally (Beck-Winchatz & Riccobona, 2008; Fraser & Maguvhe, 2008; Smith & Kelley, 2007). Also, some schools view specialized teaching materials and assistive technology tools used in the education of these students as expensive (Beck-Whinchatz & Riccobona, 2008; McCollum, 1999). Several technological tools are considered expensive, such as 3D printers, shape relief printers, and computer software to represent some concepts and shapes. It is clear that such tools are essential for effective science teaching. It may, however, be possible for the teacher to represent topics and concepts using materials and tools found in daily life and to teach effectively. Science and technology should be taught effectively to all students, whether they have visual impairments or not (Sözbilir et al., 2015). In spite of this, science education practices for students with visual impairment are incomplete, and research is needed to provide better science education opportunities to these students (Lahav et al., 2016; Wild & Allen, 2009). To design accessible teaching materials and to prepare better teaching environments for students with visual impairment, it is important to analyze the instructional needs of students. To increase the educational opportunities in science lessons for students with visual impairment, the current study aims to identify the difficulties and instructional needs of students with visual impairment. For this purpose, answers to the following questions are sought:

RQ 1) What are the challenges experienced by middle school students with visual impairment in accessing topics and concepts in science lessons?

RQ 2) What are the needs of middle school students with visual impairment in science lessons?

2. Method

2.1. Research Design

A qualitative approach was adopted into this study since it was aimed to determine the challenges experienced by students with visual impairment as well as to examine their instructional needs in science lessons. Using various data collection methods such as observations and interviews, a case study can analyze and interpret one or more situations in a certain time frame in an in-depth and holistic manner (Creswell, 2013). Therefore, the study utilized the case study method of qualitative research design.

2.2. Participants

The study consists of 13 middle school students studying at a visually impaired middle school affiliated with the Ministry of National Education in the 2021-2022 academic year, and 10 teachers. The samples were selected by using a purposive sampling method, which is a method used to select people or situations based on certain characteristics and criteria (Koç Başaran, 2017). Table 1 and Table 2 provide characteristics of the study groups. The participants who were interviewed within the scope of the study were informed about the purpose of the research, and a preliminary interview was conducted. In addition, a consent form was completed stating that the audio recordings would not be used for any purpose other than the relevant research and would not be shared with anyone other than researchers.

Table 1
Characteristics of the students

Code	*Grade level*	*Gender*	*Visual status*
S_1	5th grade	Male	Low vision
S_2	5th grade	Female	Low vision
S_3	6th grade	Male	Low vision
S_4	6th grade	Male	Low vision
S_5	7th grade	Male	Low vision
S_6	7th grade	Female	Blind
S_7	7th grade	Female	Low vision
S_8	7th grade	Male	Blind
S_9	8th grade	Male	Low vision
S_{10}	8th grade	Female	Blind
S_{11}	8th grade	Female	Low vision
S_{12}	8th grade	Female	Low vision
S_{13}	8th grade	Female	Low vision

Table 2
Characteristics of the teachers

Code	*Gender*	*Subject area*
ST_1	Male	Science teacher
ST_2	Male	Science teacher

2.3. Instruments

As data collection tools, a lesson observation form, a semi-structured student interview form, and a semi-structured teacher interview form were used. The lesson observation form and interview forms were prepared by the researchers. The researchers developed the lesson observation form by analyzing different articles, projects, and national reports in the literature and taking into account the opinions of experts. During the development process, the first draft form contained implementation, content, and classroom culture components. The assessment and evaluation component was added to the observation form as a fourth component in accordance with expert opinions, since some items in the implementation component were directly related to the assessment and evaluation component. In order to ensure construct and content validity, a 17 item observation form with three grade levels of "Yes", "Partially", and "No" was created. In addition to the observation form, the researcher also took unstructured field notes about how the lessons were taught.

To prepare semi-structured student and teacher interview questions, a literature review was conducted, informal interviews were conducted to decide on interview questions, and expert opinions were sought for the creation of interview questions. The validity of the interview questions was ensured by participant confirmation and expert review, while the reliability was ensured by confirmation review. Semi-structured interview forms included an introduction and interview questions, including the purpose, duration, confidentiality, and recording of the interview.

2.4. Data Analysis

The data obtained from student and teacher interviews was analyzed using descriptive analysis and content analysis methods. Based on the content analysis of the data transcribed into written documents, themes and codes were created. To make it easier for the reader, the theme and code frequencies are presented in matrices. To ensure reliability, two researchers coded the data and compared the codes and themes obtained. In terms of inter-coder consensus, the reliability coefficient of 0.82 indicates the data were internally consistent (Patton, 2002). For validity purposes, direct quotations from participant statements are also included.

The observation form data was analyzed using a scoring technique. One point was awarded for the items that were not observed during the entire lesson and were coded as "No", while two points were awarded for the actions performed occasionally but coded as "Partially" despite the fact that doing them fully would make the lesson more effective. A third point was awarded for the actions marked as "Yes" and the behavior indicated in the indicator of the relevant item was fully realized during the lesson. Based on the observations made during the lessons for a total of six hours, we calculated the average score for each item based on arithmetic averages. Finally, the interview data was used to determine the students' learning needs for the science lesson.

3. Results

The results of the lesson observations and semi-structured student and teacher interviews conducted to determine the instructional needs of middle school students with visual impairment are presented in this section, respectively.

3.1. Results from the Observation Form and Field Notes

On the basis of the average scores of the items belonging to the implementation, content, assessment and evaluation, and classroom culture components of the observation form used within the context of lesson observations, Table 3 presents the findings obtained from the observation form used within the scope of lesson observations to determine the instructional needs of the students.

Analyzing Table 3 in terms of the mean scores of the implementation component of the observation form, it is evident that in none of the lessons observed, students' attention was not drawn to the lesson before it was taught. Additionally, none of the lessons observed were designed to allow students to work collaboratively in groups. Aside from these, it is evident that students' prior knowledge or readiness is rarely investigated in most lessons before the subject is taught. Students' conceptual understanding was not supported by teaching methods, techniques, and strategies in science lessons, which were mostly concept-based, and, most importantly, the teaching environments and course materials used are not tailored to their visual abilities. Despite having a higher score than the other items on providing students with targeted content, the item on suitability of the designed learning environment has a very low average score.

In terms of the content component, examples from everyday life were generally used in the teaching of science subjects. However, it is noteworthy that activities that make students active were rarely included in the lessons. In some lessons, useful teaching materials were used, but other than these, students were not provided with appropriate or special materials. In the lesson, the smart board and videos were the most commonly used instructional materials. These materials

Table 3
Scores for the components in the observation form

Components and indicators	*Mean score*
Implementation	
Drawing students' attention to the subject before starting the lesson	1
Probe the prior knowledge that the student should have about the subject	1.34
The suitability of the designed learning environment to provide students with the targeted content	1.67
The method/strategy/technique used supports students' conceptual understanding	1.34
Supporting the application with group work or collaborative work where students can work together	1
Considering the visual status of students in the teaching practices and/or course materials used	1.34
Content	
Including activities suitable for teaching the acquisition	1.67
Preferring activities that make students active	1.34
Supporting the development of students' life skills such as analytical thinking, decision making and creativity	1
Include examples from daily life related to the teaching of the relevant subject	2.67
The usefulness of the teaching materials used (cost, easy accessibility, etc.)	2
Assessment and Evaluation	
Asking questions to identify student errors/misconceptions	1.34
Asking questions that encourage students to think	2
Providing appropriate feedback on student work/responses	2.33
Classroom Culture	
Giving all students the opportunity to express themselves	1.67
Giving students responsibility	1.67
Involving all students in the teaching process	1

were selected without considering the visual status of the students, resulting in a low score for the relevant item in the implementation component. Based on the results of the assessment and evaluation component, almost no questions were found that indicated errors or misconceptions that students may have. In contrast, the teacher provided appropriate feedback to students' questions and included questions encouraging them to think. However, observations showed that the teacher ignored some questions or failed to explain them clearly. The results of the classroom culture component showed that all students could not be included in the teaching process since such a learning environment was not created. It was also observed that the teaching environment was not conducive to allowing students to express themselves easily. Further, the students' responsibilities are generally limited to answering multiple-choice questions as homework and not given any responsibility for conducting research or preparing projects.

Besides the structured observation form, the unstructured observation notes taken by the researcher provide expanded explanations and examples of the observation items. In terms of the teaching environment, it is noteworthy that, despite the small class size, the classroom environment does not meet the individual needs of the students. Students with low vision were unable to access the board due to important variables such as distance to the board, amount of light, or direction of light not being taken into account; some classes were arranged in a U-shape, while others were arranged in three rows in front and two rows behind.

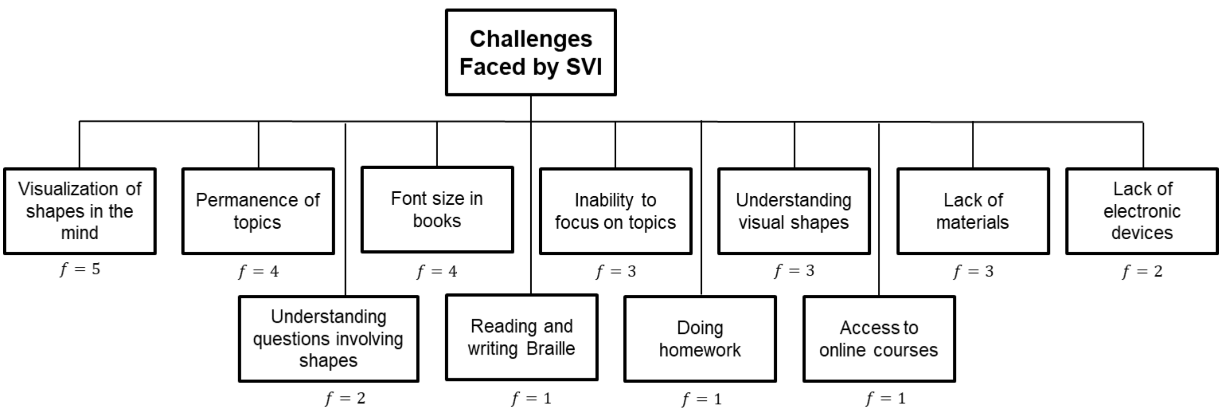
In spite of the fact that there were few students in the classes (5), individual attention was not fully realized. A second observation note that was taken for the learning-teaching process revealed that science subjects were usually explained verbally, the teacher asked questions to the students during the explanation, gave examples from daily life and asked the students to write about them. Students who were completely blind wrote with Braille writing slates and stylus, whereas students with low vision wrote in the same way since they could write more easily with these tools. It was observed that the teacher did not engage the students with any activities at the beginning of the lesson to attract their attention to the subject, but merely questioned their prior knowledge in the form of questions and answers, asked them what they had done previously and informed them about the topic at hand. In general, the lecture method and question-answer technique were used in the lessons, no other teaching methods and techniques were used, and no worksheets were given to the students at the beginning. Students played a passive role rather than actively participating in the lessons, and no activities or experiments were included from the stages of bringing attention to the subject, active endeavor, or evaluation. Although students can memorize what they hear quickly, the fact that they quickly forget the topics and concepts afterward reveals that science lessons, which are mostly taught by reading, explaining, and printing, are not permanent on students' learning.

When the observation data were analyzed in terms of the teaching materials used in science lessons, it was noted that the teacher generally followed the textbook in the lessons, watching/listening to lecture and question solution videos on the smart board or computer in some subjects, and the students followed the embossed textbooks and wrote with writing slates and stylus. It was stated that the textbooks were ineffective because the embossed books were too large and difficult for students to carry, and the embossed writings flattened over time and became illegible. Except for the textbook, no teaching materials were prepared before the lesson, and the materials available at the school were not frequently used in the classroom. In light of the students' individual visual status, it was noteworthy that no functional teaching materials or activities were prepared or adapted to assist them in better understanding the subject. As a result of examining the observation notes after each lesson to determine how much the students had learned, it was discovered that the teacher usually reads the end-of-unit evaluation questions or sample questions from the source books and the student answers them orally. It was also observed that sometimes students were given multiple-choice questions as homework, which they solved with help from their families and from the teacher on duty.

3.2. Results from the Student Interviews

To determine the individual needs that directly or indirectly affect students' learning, they were asked questions to identify the challenges they face, the way they access information, the support they receive from the school, the materials used in school, the materials used outside the school, and the activities they want to be done in the lessons. Figure 1 shows the results obtained from the challenges encountered by the students during their education.

Figure 1
Challenges faced by students with visual impairment



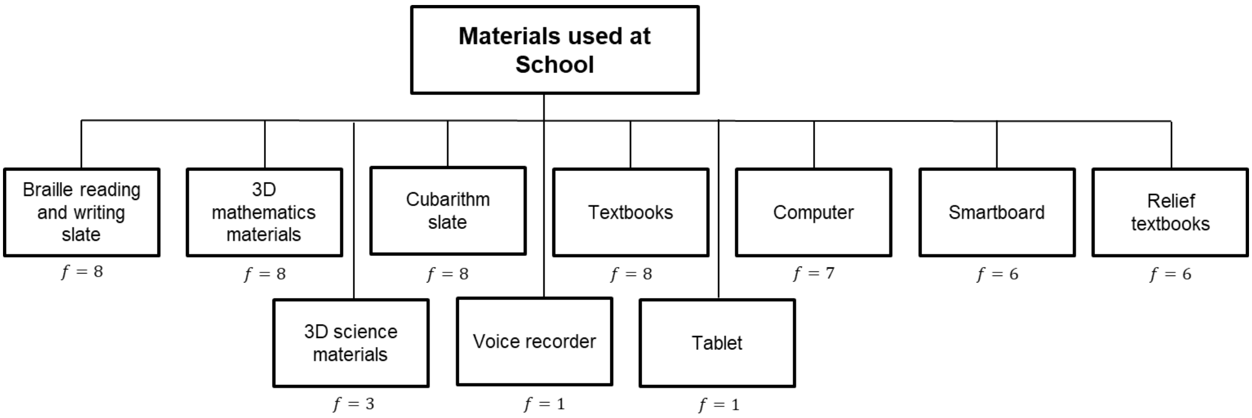
Note. SVI: Students with visual impairment.

Figure 1 shows that students stated that visualizing shapes in their minds was the most challenging issue. Even though only three of the 13 students collected data were blind, the fact that individuals with low vision said they had difficulty visualizing shapes for abstract concepts suggests that different types of materials should be used in developing lessons. In a similar vein, the students found it challenging to understand visual shapes and to understand questions involving shapes. The answer given by a student about the difficulty of making sense of the shapes is as follows:

> S13: ...I have difficulty in converting shapes into verbal because we say "tree", but we do not know what the shape of the tree looks like, its color and so on. Therefore, when we are told to think of a tree, nothing appears in our minds or when we are told to think of a pyramid, nothing appears in our minds, so learning science subjects is difficult and not permanent...

In addition, four students stated that they forgot the subjects they learned quickly and that the subjects were not permanent. In addition, some of the students asserted that the font sizes in the books were not large enough. Only one of the students stated that they had difficulty in reading and writing Braille. In another theme, students were asked to list the materials they used in school. In this way, inferences could be drawn about the unused materials. Figure 2 shows the results.

Figure 2
Materials used in school

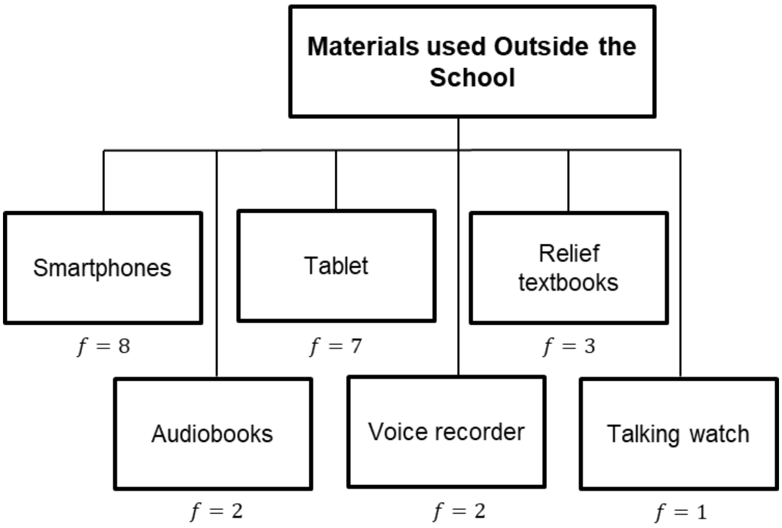


When the students were asked which materials they used at school, it was observed that the most commonly used materials were Braille reading and writing slates. One of the most frequently repeated response was 3D-mathematics materials. However, only three students stated the same type of science materials. Textbooks were among the most commonly used materials, followed by computers, smart boards and relief textbooks. The least recurring materials were voice recorder and tablet. There are some important findings in the student responses regarding the types of materials that can be used to enrich the lessons. For example, one student's response is as follows:

> S3: ...I have never seen such tools and equipment, but there is a microscope, our teacher showed it last year, but he did not show it at all this year in Grade 5. This year the teacher did not show any tools and equipment in science. She explains verbally and makes them write. At school, the teacher opens the smartboard for a face-to-face lesson, and I can watch it from there…

In addition to the tools and materials used at school, students were also asked what kind of tools and materials they use outside of school. The data obtained are summarized in Figure 3. The findings summarized in Figure 3 show that the most frequently used materials in out-of-school settings by the majority of students are technological devices, namely smartphones and tablets. This also indicates that students, like their peers, use popular learning tools for learning purposes. In addition, Braille books, audio books and voice recorders were identified as out-of-school materials used by a limited number of students. One of the students stated a talking watch.

Figure 3
Materials used outside the school

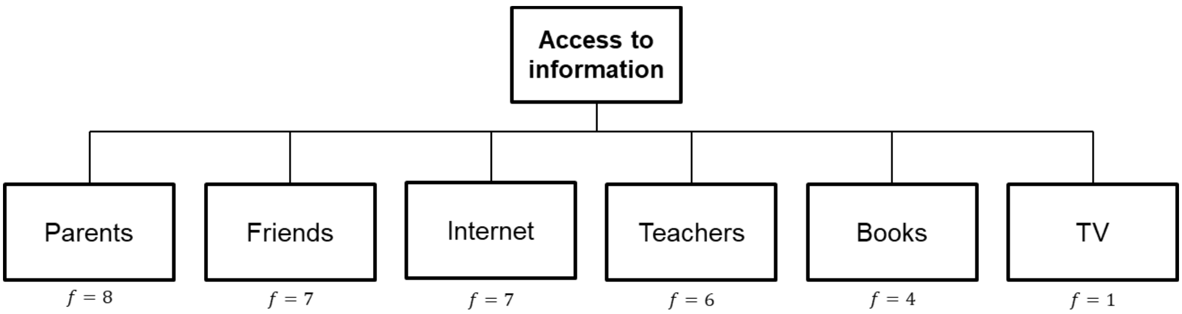


A sample student response on the issue is as follows:

> S7: ...There is something called a voice recorder, I use it, I use a talking clock, my mother bought me an audiobook and I listen to it. I used to use it on the phone but it doesn't work properly. I know how to use a computer, but I can't use it because there is no software for me to use...

With a different question in the data collection tool, students were asked about the ways they accessed information. With this question, it was aimed to make indirect inferences about the ways students followed to overcome the difficulties they experienced in the process. The data obtained are summarized in Figure 4.

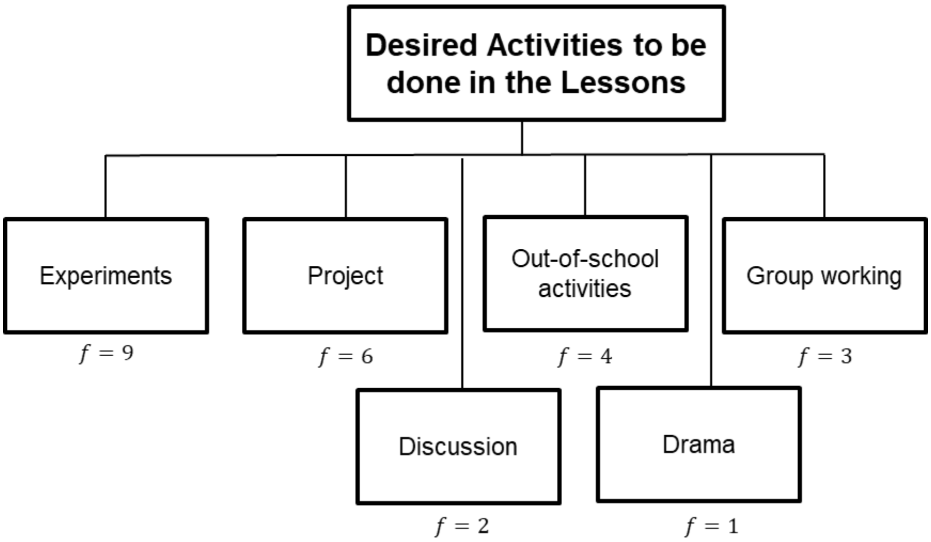
Figure 4
Students' ways of accessing information



Student responses show that the biggest source of information used by students to access information is their parents. In addition, it is seen that friends of students with visual impairments are their biggest supporters in the process. Some of the students stated that they use the internet to improve their knowledge or to learn new information. As an interesting data, the teacher comes after these sources of information. Approximately one third of the students stated that they use books to access information, while one student answered television. For example, S6 stated that "...I get help from my parents and so on. They read it, I tell them to write it down and they write it down. At school, I have a friend read it and write it down..."

Finally, the students were asked what activities they would like to see in the lessons. The codes and frequencies obtained for this theme are shown in Figure 5.

Figure 5
Activities that students would like to see in the lessons



As can be seen in Figure 5, it is seen that most of the students want to conduct experiments in the lessons. Almost half of the students stated that they want to do projects. While some of the students stated that they would like to do out-of-school activities, three students stated that they would like to be a part of group work. Two students emphasized the need to create discussion environments in the lessons, while one student said that they would like to see drama. Undoubtedly the most striking finding here is the students' desire for experiments. In this sense, one of the students who expressed this desire during the interview is as follows:

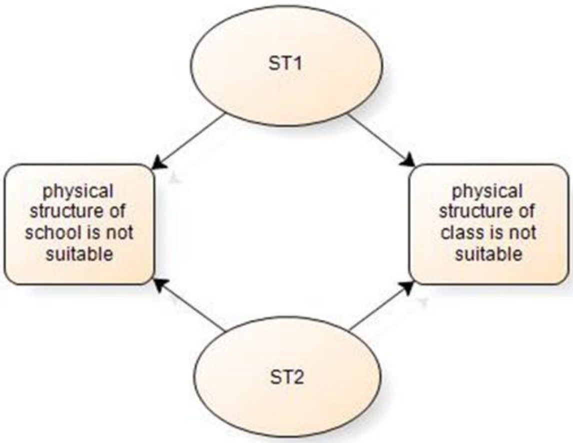
> S10: ...The lessons appeal to us, but they are not very permanent because we can do something not only by listening and commenting but also by thinking about how we can find solutions to these environmental problems, but these are not allowed because we are visually impaired. For example, we can make appropriate materials and prepare a diagram for an environmental problem such as explaining the melting of glaciers due to air temperature. You can put water in a container and throw ice in it, this can be done by the students. They can show that it melts when placed in the sun on a summer day, this experiment can be done for young children...

3.3. Results from the Teacher Interviews

To understand the challenges faced by middle school students with visual impairments in engaging with science subjects and concepts, as well as their specific needs in science lessons, interviews were conducted with their science teachers. The aim was to gather their perspectives on the teaching methods, techniques, and strategies they employ, as well as the teaching materials and activities they use while instructing these subjects. Additionally, insights were sought on how they assess students and whether the subjects and learning objectives in the current curriculum are suitable for students' learning or how they should be adapted. Analysis of the interview data revealed various needs related to the teaching environment, instructional process, and assessment and evaluation, leading to the formation of key themes. In the context of the teaching environment theme, Figure 6 presents teachers' views on whether the physical structure of the school and classroom where students with visual impairments study is suitable for them.

Figure 6

Views of two science teachers on the teaching environment

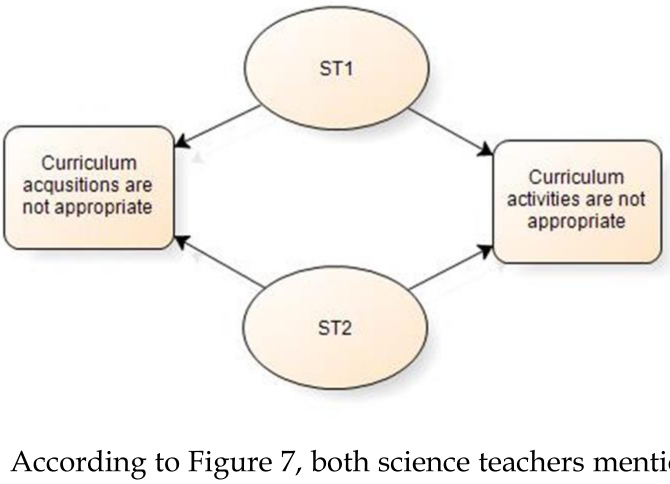


According to Figure 6, both science teachers mentioned that the school where students with visual impairments learn is not suitable for them. While the large size of the school and wide corridors are seen as advantages for the students, the main issue is the multiple floors and stairs. The teachers noted that new students especially struggle with navigating the stairs to reach other classrooms, the dining hall, and the dormitory. Additionally, there are several shortcomings, such as the science laboratory being unused, in disrepair, and converted into a classroom, and the computers in the technology class being outdated due to unupdated software versions. In the classrooms, the absence of a blackboard means the students' positions relative to the board and the angle of light are not as crucial, and the classroom environment becomes more suitable as the students become accustomed to the arrangement of objects. One of the teachers, ST_2 asserted that "We don't have much to do with the board because we don't use it. At most, when activities are done on the smart board, the children like activities such as drag and drop, true and false, matching."

Based on the data obtained from the interviews conducted with teachers in the context of the teaching process theme, sub-themes emerged regarding whether the subjects and curriculum acquisition and activities are suitable for students (see Figure 7), teaching methods or techniques used in science courses (see Figure 8), teaching materials used in science courses (see Figure 9), and the difficulties encountered in the teaching process (see Figure 10).

Figure 7

Views of two science teachers about the curriculum acquisition and activities

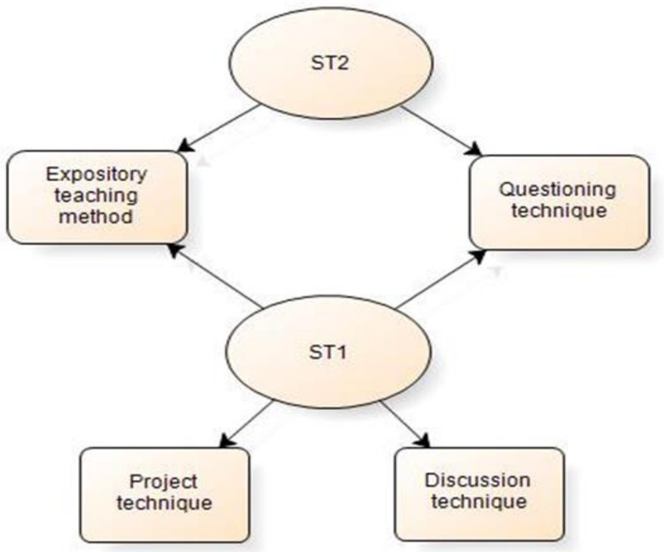


According to Figure 7, both science teachers mentioned that the topics, objectives, and activities in the science curriculum were not very suitable for students with visual impairments. Generally, the teachers noted that certain outcome stems, such as "sees" or "draws," were inappropriate, it was challenging to cover all the topics, and some activities were not feasible for the students. They also pointed out that some of the acquisitions and acquisition roots in the curriculum were unsuitable, and many activities were difficult for students with visual impairments as they were designed for the general public. In this manner, ST_1 stated that:

> I think that some outcomes are not appropriate. For example, the outcomes written in the annual plans, like 'draws the circuit element,' seem problematic. Of course, this is partly our responsibility, as we refer to these annual plans as IEPs (Individualized Education Plans) or we organize them ourselves. While we do organize these plans, I still feel uncomfortable writing such outcomes in the annual plan. When I write the acquisition root 'sees,' I wonder how these children will see and how they will draw. I believe the activity and subject matter itself may be sufficient for the student, but the program is designed for the general public. Of course, different materials can be developed. There are acquisition roots that are directed at the general audience, like seeing and drawing, but there is no acquisition specifically designed for visually impaired students. In fact, science subjects are very suitable for designing and creating projects. However, when I look at the activities, I don't think they offer much opportunity for these children in this regard...

The findings obtained from the teaching methods or techniques used in science lessons are as shown in Figure 8.

Figure 8
Teaching methods or techniques used in science courses

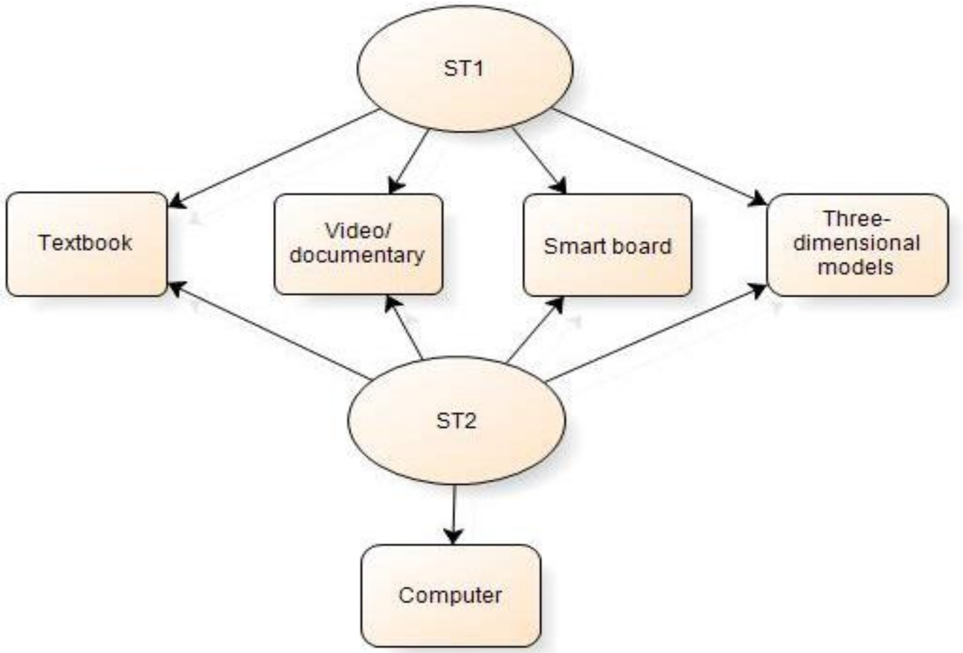


When analyzing the codes for the sub-theme of teaching methods and techniques used in the lessons, it is evident that the majority of teachers rely on verbal (direct) expression methods and question-answer techniques in their lessons. One science teacher, however, incorporated techniques such as discussion and having students prepare projects. Overall, based on the teacher interviews, it is clear that science lessons lack experiments, activities, group work, project work, problem-solving, or out-of-class activities. In this sense, ST_1 stated that:

> … We generally prefer verbal expression in lessons. We opt for observation rather than experiments and activities. For example, children can notice air pollution in the winter months. The smoke from the stove makes it hard to see. Since the children mostly come from the rural areas of Adana, from neighborhoods with low socioeconomic status, where there is a lot of coal burning, they can observe this. However, in areas with better socioeconomic conditions, where natural gas or air conditioning is commonly used, you don't see much air pollution. We can't take them out and observe things much because it's difficult to move these children collectively from one place to another. At most, we can take them to our garden or, as I said, we explain things using verbal examples. We try to connect more with examples from daily life, and this is basically what we do...

The findings related to the teaching materials used in science lessons are presented in Figure 9.

Figure 9
Teaching materials used in science courses



The analysis of the codes related to the sub-theme of teaching materials used in the lessons shows that textbooks are primarily used, though source books and three-dimensional models/materials are also employed in some lessons. Both teachers mentioned that they occasionally use the smart board to watch/listen to videos and documentaries in their lessons. In science lessons, it is noted that teachers mostly present ready-made materials, such as DNA models, cell models, and batteries, to students. However, they do not incorporate teaching materials that can address individual needs and enhance learning when teaching subjects and concepts. For instance, ST2 stated that:

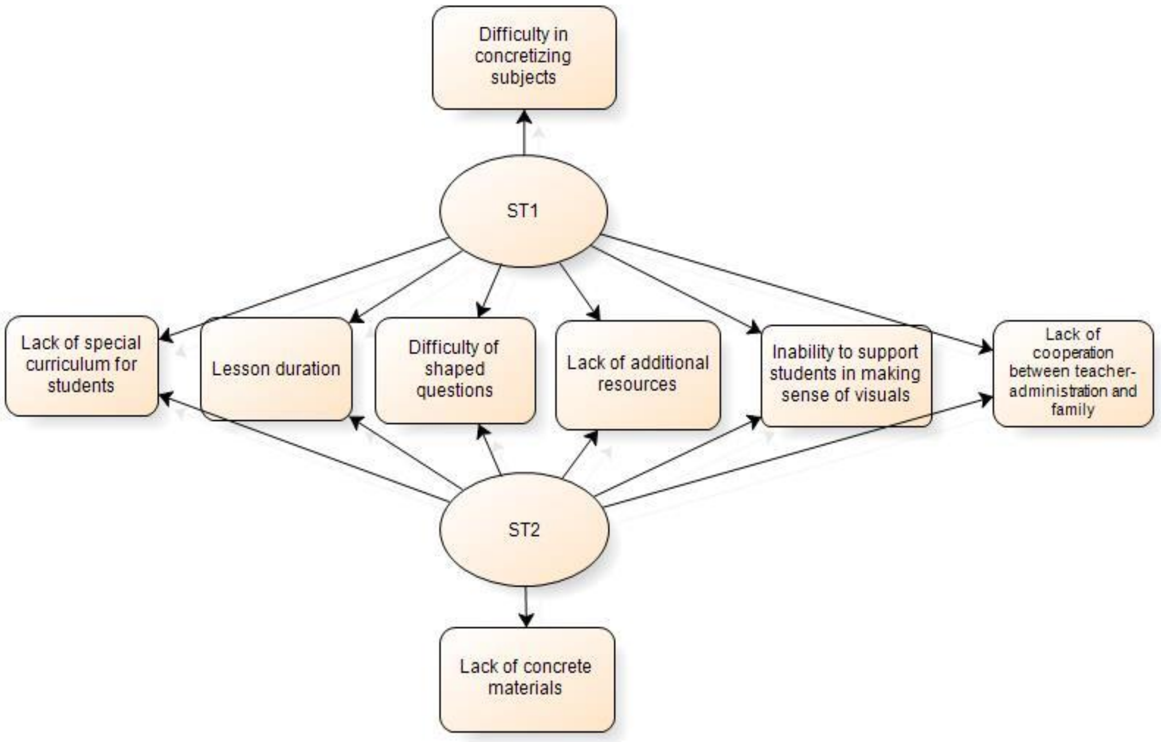
> We don't use many different materials. We use a smart board and listen to it from there. We have never used any concrete materials. Whatever is needed in the classroom at that moment, we either bring it from the laboratory or use what's available. As I mentioned, it's mostly physical items. For example, when explaining sound or electricity, if a student doesn't know what a diapason is or needs to understand electrical devices, we use batteries from the laboratory. Also, if a student is having trouble understanding, I can spontaneously create materials from paper, pencils, erasers, or rulers during the lesson.

The findings related to the difficulties experienced in the teaching process of science subjects are summarized in Figure 10.

The difficulties experienced in the teaching process are reflected in codes such as curricula not being specific to students, lack of course equipment, time constraints, difficulty with complex questions, shortage of additional resources, issues with making visuals concrete for students, and lack of cooperation between school and family. Additionally, challenges like the absence of concrete materials and the inability to make subjects more tangible for students were also identified. It is evident that teachers generally face difficulties in making subjects more concrete or explaining them in a way that students can easily understand. This is especially true because

Figure 10

Difficulties/problems experienced in the teaching process of science subjects



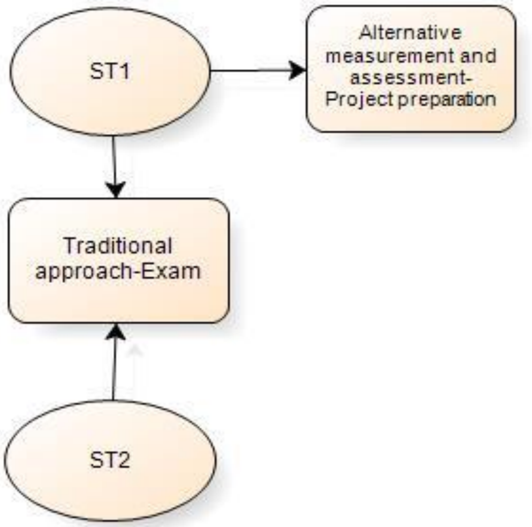
students struggle with science subjects due to their abstract nature, highlighting the need for more concrete examples. The statements of both teachers on this matter are provided as follow:

> ST_1: …It is difficult to make sense of it because children do not see it. The child doesn't see the machine. If you call it a pulley or a lever, it is very difficult for him to understand because he cannot see. One per cent of the students in Turkey are visually impaired. A one percent group is asked to benefit from a programme prepared for ninety percent students. Therefore, we have difficulties. These children are in a race with normal children, we put them in the exam as if they have no disadvantages, but they cannot do the shaped questions. But there is no extra effort or resource to overcome the disadvantage of this child. No extra programme was prepared. They put the same book in front of him as the other child, saying, 'Come on, you are responsible for this'. However, these should be improved…

> ST_2: …Of course, science subjects remain abstract, making it difficult for students to understand. Not all children learn in the same way. A child with low vision can see things on TV or in their surroundings, and at least when explained, they can make it more concrete and understandable. However, a child with no vision doesn't have that opportunity, so they should be supported more with materials."

Finally, the data obtained from the interviews conducted with teachers in the context of the assessment and evaluation theme are presented in Figure 11. The analysis of the sub-themes and codes related to the assessment and evaluation theme shows that, as a traditional evaluation method, students are primarily assessed through exams to determine if they have learned the

Figure 11
Teachers' views on assessment and evaluation methods



subjects. Additionally, as an alternative form of assessment, students are evaluated through project homework. Both teacher responses are as follows:

> ST_1: We give exams and also assign project tasks. The exams are written, and we include fill-in-the-blank, true-false, and multiple-choice questions. Those who can write do so, and for those who cannot, we find a printer or write it ourselves. Totally blind students write their answers in braille, using a tablet and a cuneiform pen. Then, we have the answers read either by ourselves or by someone who can read Braille.

> ST_2: We use traditional assessment. We also use alternative assessment as process assessment, although not very much. We do not do very detailed assessment, we only give projects and homework.

4. Discussion and Conclusion

Through interviews with secondary school students with visual impairments, their science teachers, and lesson observations, the study aimed to identify the difficulties students face in accessing subjects and concepts in science lessons and their specific needs in this regard. The interviews with the students revealed that the materials used at the school were mainly textbooks and Braille books. Additionally, since the study was conducted during the aftermath of the COVID-19 pandemic, computers were another widely used resource. Textbooks are considered one of the core materials in education, and some researchers argue that textbooks have a special role in transferring societal designs to current and future generations (Anvar, 2022). On the other hand, in Finland, one of the successful countries in PISA, although textbooks are theoretically considered a basic material, it is emphasized by various researchers that these materials are not used extensively in real classroom environments (Uyan, 2005 as cited in Çalışkan & Toyran, 2020, p. 695). These research results are generally accepted for individuals with normal vision. However, although limited, a few studies have examined the role of textbooks for individuals with visual impairments and disabilities. In a study by William (2021), the use of science and mathematics textbooks by students with visual impairments was investigated through data collected from various stakeholders (school principal, students, and teachers). The study's results highlighted that while textbooks are useful for individuals with visual impairments, the lack of sufficient tactile drawings and pictures is a significant disadvantage. As a result, it was recommended that three-dimensional (3D) models be used in lessons alongside tactile graphics and pictures. The results of the current study indicate that three-dimensional materials are limited or used sparingly in science lessons. In light of this, it is suggested that an integrated approach be adopted in lessons, combining information from textbooks with tactile graphics and incorporating 3D materials suitable for the learning outcomes.

Another result from the study is the difficulty, although mentioned by a small number of students, in visualizing the shapes and events described to them or their inability to perform this action. Compared to individuals with low vision, those who are completely blind lack a mental image of objects due to their inability to see the surrounding environment. Instead, they attempt to form an image using their tactile sense and, at times, their sense of hearing (Fisher & Hartmann, 2005). Given that the primary shortcoming in science education for students with visual impairments is the lack of materials addressing different sensory organs (Sahasrabudhe & Palvia, 2013), it is evident that there is a need for learning environments that help students build concepts in their minds. Indeed, when students were asked whether the teaching on environmental problems engages different senses, the majority of participants responded negatively, reinforcing this need. While discussions on these needs in science education for students with visual impairments are not new in our country (Okcu & Sözbilir, 2016), the repeated emergence of this need in current studies suggests that little progress has been made in resolving the issue. Student comments about the teaching process indicate that science lessons are primarily delivered through verbal explanations. Studies conducted not only with students with visual impairments but also with individuals with normal vision have shown that this issue remains an insurmountable obstacle, even though the educational philosophy of our country has evolved (Şencan, 2019). It is recommended that science concepts, which are expected to be supported by various models and taught by making their abstract structures more concrete, be enriched with diverse materials, considering the visual levels and functional vision status of individuals with visual impairments (Nam et al., 2012).

When students were asked what kind of science lesson they would like to have, the fact that most of them expressed a desire to conduct experiments can be interpreted as an indication of their willingness to learn science and their awareness of different teaching approaches. The belief that students with visual impairments cannot grasp science concepts is a common misconception, which some studies have shown even teachers hold (e.g., Fraser & Maguvhe, 2008). This results suggests that the science teacher may have shared this misconception, which influenced the structure of the science teaching. In this context, observer notes and teacher interviews provide crucial data. The observer notes revealed that the teacher primarily used lecture and question-answer techniques in the lesson and did not incorporate any concrete materials. Instead, the teacher showed videos from a private publishing company on the smart board. The interview results further confirm that the science teachers did not include experiments or activities in their lessons. It is widely recognized that teachers have professional needs when it comes to teaching practices (Nakajima & Goode, 2019). The results obtained should not only be interpreted as a deficiency in teaching practices that make learning meaningful for students but should also serve as a point of consideration for future research, particularly in professional development programs focused on teaching science to students with visual impairments. Science, being a discipline that relies heavily on observations and experiments, develops through generalizations derived from these actions. For this reason, science is often referred to as an experimental science (Kırpık & Engin, 2009). Experiments play a crucial role in making science, which inherently involves many abstract concepts, meaningful for students with visual impairments (Yazıcı & Sözbilir, 2020). According to Tuncer and Altunay (2009), materials and experiments must be adapted in a way that allows students with visual impairments to effectively learn science topics and concepts. Bülbül and Sahyun (2009), who state that these individuals can successfully conduct experiments when the necessary environment and conditions are prepared, underline that even the experiments that are said to be impossible can be successfully completed by individuals with visual impairment. The findings obtained from this study showed that students with visual impairment stated that they wanted to do experiments in teaching science subjects, while the findings obtained from observations showed that no experimental activities were included. One of the reasons why teachers do not include such activities may be that they do not know how to adapt existing experiments to make science concepts meaningful for students with visual impairment. As a matter of fact, in the interviews conducted with the teachers, it was emphasized that experiments should be available even though they do not apply them in their lessons. Another finding is that students are aware of effective science teaching techniques.

Another significant finding from the study is that students expressed a desire to engage in project work. Interviews with the students revealed that some of them enjoyed collaborating with peers on projects in other subjects (such as music). It is recommended that such approaches be incorporated more frequently into science teaching for students with visual impairments (Fraser & Maguvhe, 2008). Considering all these factors, it is believed that designing an environment enriched with experiments and integrating multisensory materials into the learning process will foster meaningful learning (Kroes et al., 2016) and increase student motivation (Plazar et al., 2021), as suggested in the literature.

Both lesson observations and interviews with students and teachers indicate that teachers face challenges in providing effective science instruction for students with visual impairments. In fact, conducting lessons primarily in the form of lectures is not considered an effective method for either students with visual impairments or students with typical development. This finding highlights the need for teachers to receive support in understanding how science concepts should be taught to students with visual impairments. Therefore, it is recommended that, for future research, science teachers of students with visual impairments be equipped with the necessary skills through in-service training programs.

5. Limitations and Future Research

Although the findings of the study monitor the difficulties and instructional needs of students with visual impairments in science lessons, it is important to be aware of some significant limitations when interpreting the results. First, the study is limited to interviews with a limited number of students with visual impairment and their teachers. Conducting future studies with larger samples will increase the generalizability of the results obtained. Second, the data gathered from observations are limited to six hours of observations. While six hours of observation can be considered to evaluate a teacher's teaching quality, a longer observation period could offer more comprehensive insights into the teaching of various acquisitions. Finally, the qualitative approach adopted in the present study aimed to reveal the current situation. Quantitative studies with broader participation could further support and validate these results.

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Data availability: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declaration of interest: No conflict of interest is declared by the authors.

Ethics statement: The authors declared that the current study was ethically approved by Trabzon University, Social Sciences & Humanities Research and Publication Ethics Board on 04.05.2020 with the approval code: 81614018-000-E.153.

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