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The voice of visually impaired students: Differentiated mathematics instruction in an inclusive class

Sumbaji Putranto[a,b*], Marsigit[a**], Elly Arliani[a***]

[a] *University Negeri Yogyakarta, Faculty of Mathematics and Natural Science, Yogyakarta, Indonesia*
[b] *University Islam Negeri Sunan Kalijaga, Faculty of Tarbiyah and Teacher Training, Yogyakarta, Indonesia*

Introduction. Previous research showed that inclusive education faces several barriers, especially among Visually Impaired (VI) students in mathematics learning. Teachers can use students' voices to increase student engagement and provide new perspectives on learning. *Objective.* This study aimed to explore the voices of students with Visual Impairment (VI) about differentiated mathematics instruction in inclusive classes. *Method.* This study is phenomenological research, with interviews as a data collection method. The participants were selected using purposive sampling, consisting of four low-vision students and six blind students aged 16-18 years. The data were analyzed through data reduction, data presentation, and drawing conclusions. *Results.* The results showed that VI students understand the concept of Differentiated Instruction (DI). They argued that good mathematics learning is achieved through detailed explanations from the teacher and hands-on activities. VI students need process differentiation but do not need content differentiation. Several things that must be considered in differentiated mathematics instructions are: 1) using the learning media that can help understand material related to graphics, 2) the teacher's ability to explain material related to graphics, including making mathematics content simpler, and 3) conditioning of the learning environment to ensure class safety and VI students sitting next to sighted peers. *Conclusion.* The findings affirm conclusions from several previous studies that students with VI show high self-efficacy in differentiated mathematics instruction. This is shown by students' confidence in their abilities so that they do not require content differentiation. The findings also affirm previous research regarding the need for learning media for VI students' hands-on activities.

Keywords: students' voice, visually impaired, differentiated instruction, inclusive class, mathematics

Correspodence: Marsigit, marsigit@uny.ac.id
* https://orcid.org/0000-0003-3492-4052
** https://orcid.org/0000-0002-8772-0750
*** https://orcid.org/0000-0001-6887-1791

Introduction

Research Background

Inclusion can be described as a program that helps schools adapt to the student's diversity. Students with special needs must be placed in regular schools and allowed to participate, which is why inclusive education is currently one of the main issues in many countries in reducing segregated education for students with special needs (Hardy & Woodcock, 2015). Nevertheless, it is not limited to providing relevant education for students with special needs but is also concerned with improving the quality of education for all children (Qu, 2022a, 2022b). Many researchers' findings indicate that inclusive education faces several barriers, so studies on inclusive education are still important (Göransson & Nilholm, 2014; Nilholm, 2021; Putranto et al., 2024a).

Through an inclusive education policy, an increasing number of Visually Impaired (VI) students attend public schools. Visual impairment refers to significant vision loss, even though corrective lenses are used. The latest findings from the International Agency for the Prevention of Blindness (IAPB) in 2020 showed that 32 million children or adolescents worldwide experience visual impairment, either blindness or low vision, from moderate to severe conditions. In line with that, data in Indonesia shows that the most common type of disability is VI, which is 63.7% of all people with disabilities (Bappenas, 2021).

The field of mathematics education has long recognized the importance of inclusive education (Roos, 2019), including that for VI students (Baykaldı et al., 2023; Klingenberg et al., 2020). Mathematics is one of the essential subjects that must be learned in school (Bacolod-Iglesia et al., 2021; Sevindir et al., 2014; Skagerlund et al., 2019) and an important component of science, technology, and engineering (Rozgonjuk et al., 2020). It helps develop creativity, reasoning, critical thinking, and problem-solving (Bilal, 2017). It is a well-known fact that VI students and their sighted peers can both follow the regular curriculum, but the VI students' visual problem is affecting their learning ability in mathematics. This is because many basic mathematical concepts are related to visual phenomena (Jones, 2018; Smith & Smothers, 2012). Vision is one of the primary senses that can support the development of students' mathematical concepts and procedures (Emerson & Anderson, 2018). Additionally, many mathematics learning practices have not optimally accommodated VI students' needs (Rosenblum et al., 2018). Also, the vast majority of teachers experience difficulties in managing heterogeneity in inclusive classes (Costello & Boyle, 2013; Webster & Blatchford, 2015). It can be challenging for teachers to be able to address the diverse needs of each student in the mathematics class (Hackenberg et al., 2021; Maulana et al., 2020).

In order to develop mathematical competence and facilitate heterogeneity in inclusive classes, including VI students, teachers can use Differentiated Instruction (DI). DI is one of the pedagogical frameworks that has promoted equitable education for a more cohesive society (Griful-Freixenet et al., 2021). In Indonesia, DI has been mandated in the national curriculum, Kurikulum Merdeka (Merdeka Curriculum), stated in The Ministry of Education, Culture, Research, and Technology Regulation in 2022. DI refers to student-centered learning that uses student differences as the basis for lesson planning (Hunter et al., 2020) and teaching processes guided by a constructivist approach (Wan, 2017). It is an approach that provides students with multiple options to receive and process information to make learning happen. Differentiation adapted content, process, and product according to students' interests, readiness, and learning profile (Jarvis, 2013; Tomlinson, 2001; Tomlinson et al., 2013). The key to success in differentiation includes a positive learning environment, a high-quality curriculum, tiered tasks, scaffolding, adaptive learning materials, and enhancing flexibility in classrooms (Guay et al., 2017; Jarvis, 2013; Tomlinson et al., 2013; Ziernwald et al., 2022).

In the current era, DI in mathematics classes is one of the important strategies to implement (Bal, 2023; Kokkinos & Gakis, 2021). Previous research has proven that differentiated mathematics instruction (DMI) supports the needs of diverse students (Hackenberg et al., 2021), serves as an effective approach to a solution to students' difficulties (Papanthymou & Darra, 2022), and has many benefits in improving students' academic achievement (Afilin, 2023; Bobis et al., 2021; Jamil et al., 2024; Lai et al., 2020). DMI makes students try to utilize their abilities to learn mathematics. This makes students more confident in expressing their opinions, being more persistent, and more actively involved in mathematics tasks and projects (Putranto et al., 2024b).

To optimize DMI, teachers must consider students' voices because they have different experiences in the class (Parr & Hawe, 2022). Students' voices can increase their engagement and provide new perspectives for teachers (Charteris & Thomas, 2017; Keddie, 2015), which has an impact on improving the class's learning quality (Ferguson et al., 2011; Graham et al., 2018; Messiou & Ainscow, 2020). However, previous studies have shown that many countries do not commonly use students' voices in educational practices (Forde et al., 2018; Simmie et al., 2019). Based on this condition, the researcher considered it important to explore VI students' voices regarding DMI. The study is essential to develop student-centered learning practices (Baroutsis et al., 2016). Therefore, it can develop the engagement of VI students and provide opportunities for them to improve their mathematics competence.

Aim

This study aimed to explore the voices of students with Visual Impairment (VI) about differentiated mathematics instruction in inclusive classes.

Research Question

Students' voices are not a common research topic since previous studies have focused on teachers' perspectives. This study is realized with an aim to answer two research questions.

1. How do VI students perceive and understand differentiated mathematics instruction?
2. How good is differentiated mathematics instruction from the perspective of VI students?

Method

This is qualitative research with a phenomenological design. The choice of research type is based on the argument that qualitative research is best used to provide feedback on data about group perceptions, beliefs, and experiences (McDuffie & Scruggs, 2008). Phenomenology was chosen with the argument that this approach allows researchers to develop impartial views and detailed rationale (Husserl, 1970). This study aimed to explore VI students' voices of perception and understanding of DMI.

Sample

This study involved ten VI students at an inclusive Madrasah Aliyah (Senior High School) in Yogyakarta, Indonesia. The participants were selected using purposive sampling. The sample consists of four low-vision students and six blind students aged 16-18 years. The main information about the participants is presented in Table 1.

Table 1

Research Participants

No	Initial Name	Gender	Grade	VI Category
1	AL (Subject 1 – S1)	Female	X	Low Vision
2	TK (Subject 2 – S2)	Female	X	Low Vision
3	FMSN (Subject 3 – S3)	Female	XI	Totally Blind
4	FAR (Subject 4 – S4)	Female	XI	Low Vision
5	IKh (Subject 5 – S5)	Male	XI	Totally Blind
6	IM (Subject 6 – S6)	Male	XI	Low Vision
7	NK (Subject 7 – S7)	Male	XI	Totally Blind
8	WIM (Subject 8 – S8)	Male	XI	Totally Blind
9	NES (Subject 9 – S9)	Male	XII	Totally Blind
10	WA (Subject 10 – S10)	Male	XII	Totally Blind

Instruments and Procedures

This study used interviews to collect data. Interviews are a key element of data collection in phenomenological research (Creswell, 2007; Kvale & Brinkman, 2009). Semi-structured interviews were used because of their flexibility, which allows the researcher to add questions during the interview and provide more in-depth data (Creswell, 2007). The students involved in the research were interviewed to gain an in-depth understanding of their perceptions and understanding of DMI. Three experts evaluated the key questions in the interviews. Table 2 lists the key questions used in this study.

Table 2

Interviews Key Question

No	Research Question	Interviews Question
1	RQ 1	Do you get math lessons that are different from your friends in general?
2		Can you explain the meaning of differentiated and adapted instruction to the needs of the students?
3		Explain how you can learn well (listening to explanations, simple physical activities, kinesthetics, or others), and has the teacher provided learning facilities that suit your learning needs?
4		Do you feel the material you learn is helpful in your life? Can you explain?
5	RQ 2	Does the teacher present the material in various ways to help you study more effectively? Do you think it is necessary to differentiate?
6		Does the teacher present a different level of material difficulty than what you get with your friends? Do you think it is necessary to differentiate?
7		Does the teacher conduct assessments differently according to your needs? Do you think it is necessary to differentiate?
8		Are you used to solving mathematical problems related to daily life? Does it help your study (solving mathematical problems in daily life helps students learn mathematics during school classes)?
9		How do you feel about your learning environment, and what do you want?
10		Are there any deficiencies in the learning process that have occurred? What enhancement should be undertaken?

Interviews were conducted alternately for each participant. The interviews took 25 to 45 minutes via face-to-face, telephone, or WhatsApp voice notes. Before the interview was conducted, the researcher explained the purpose of the research and

informed the participants that the interview would be recorded. The recording results will not be used other than for research results and will not be shared with anyone other than researchers.

Data Analysis

Phenomenological research begins with identifying the phenomenon (Moustakas, 1994). The data were analyzed by adapting the Miles et al. (2014) procedure. The analysis begins with data reduction by selecting, focusing on simplification, abstraction, and transformation of raw data from the interview results. The data is presented as structured information that allows conclusions to be drawn, for example, in the form of a table. In the final stage, conclusions are drawn.

The credibility of this study was carried out using member checking (Creswell & Miller, 2000). The transcribed data were sent to participants for confirmation and feedback. On the other hand, detailed descriptions of the data collection procedures and data analysis are used to demonstrate transferability and confirmability (Algolaylat et al., 2023). Meanwhile, an internal audit of the entire research process was conducted to demonstrate the dependability.

Results

This research explored VI students' understanding and needs regarding differentiated mathematics instruction. Apart from that, it will also explore what can be made to improve differentiated mathematics instructions from VI students' perspective. Therefore, three main themes are this research's findings: 1) VI Students' Perspective on DI; 2) DI Dimensions of VI Students; and 3) Improving Differentiated Mathematics Instructions.

VI Students' Perspective on DI

VI students provided varied perspectives and definitions of DI. Besides that, they understood and could identify how they learned. They state that DI provided benefits in developing mathematical abilities. The first and the second question gather general information about the VI concept of DI. There were three perceptions about DI. S1, S6, and S8 defined DI as "learning adapted to the needs of students". While S3 and S5 explained DI as "learning adapted to the abilities of students". The other subjects (S2, S4, S7, S9, and S10) described DI as a "different learning process". Table 3 shows how VI students understood differentiated mathematics instruction.

Table 3

VI students' understanding of DI

Concept of DI	Frequency
Learning based on students' need	30 %
Learning based on students' ability	20 %
Differentiation learning process	50 %

The third question was designed to determine whether students know their learning styles and whether they can identify appropriate instruction. All VI students explained that the best way to learn was by listening to the detailed explanations from the teacher. Moreover, S9 and S10 revealed they could also understand mathematics well through hands-on activities. Some of the VI students also learned by looking for additional references. For instance, S6 and S7 explained that they would look for supplementary online material.

The fourth question relates to students' perceptions of DI and whether it is beneficial. All participants agreed that DI helped them in learning mathematics. However, VI students argued whether DI makes it easier for them to associate mathematics with their daily lives. There are two opinions: some of them said that math materials were related to their daily lives, while others said they were not.

DI Dimensions of VI Students

Questions 5 to 7 explore the required dimensions of differentiation in mathematics instruction from VI students' perspective. The result is shown in Table 4. All of the participants said that teachers must differentiate the learning process between students with VI and their sighted peers. S3 revealed, "If mathematics material has many visuals, I think the teacher must explain more detail for VI students. Thus, I can understand the material."

Table 4

The need for DI from the perspective of VI students

Differentiated Instructions	Agree	Disagree
Process Differentiation	100 %	0 %
Content Differentiation	10 %	90 %
Evaluation and Product Differentiation	70 %	30 %

Further findings explain that most of the participants agreed that content should not be differentiated between VI and sighted students. S3 revealed, "As long as it is accessible, I do not need to be differentiated because the cognitive abilities of blind people are similar to others". In addition, S6 stated, "The material does not have to be differentiated. It shows equality in learning". For the evaluation dimension, VI students explained that several things needed to be

appropriate to their needs, including 1) the teacher minimized problems using graphics (S3); 2) the collection of answers was also differentiated (students with disabilities were given questions, and the answers were sent on WhatsApp, while the other friends wrote on paper) (S2 and S6); 3) the questions used for VI students were multiple-choice since the process of answering and submitting answers becomes easier for them this way (S6).

Improving Differentiated Mathematics Instructions

Questions 8 to 10 explored well-differentiated instruction from the perspective of VI students. At the beginning of the interview, all participants agreed that they felt comfortable with the mathematics learning process in the class. S3 stated, "It has been very comfortable; everyone gave me full support". In addition to teachers, the sighted students in inclusive classes also provided support for VI students. In line with this, S2 expressed, "I feel happy when learning mathematics because teachers are very supportive". The results of the interviews revealed that teachers and sighted students often provided positive affirmations for VI students. In addition, VI students were encouraged to participate in group tasks.

Question number 10 could reveal three main themes that must be considered to make DI more effective for VI students (Table 5). First, it needed to develop media that can help understand graphics materials. S1 revealed, "For materials that use graphics, the media is still limited". On the other hand, S2 said, "What is still difficult to understand is when it comes to graphic material. It isn't easy to understand because we do not know what it looks like. Media should be provided that can make VI students understand graphics". VI students most frequently mentioned the availability of media for hands-on activities. They said that this media helped them understand the material better. This becomes necessary to differentiate in mathematics learning, especially material related to graphics, geometry, etc.

Table 5

The need to improve DMI from VI students' perspectives

The VI students' needs	Frequency
Increasing the availability of learning media for hands-on activities	80 %
Improving teachers' ability to communicate and facilitate VI students	30 %
Improving class management	50 %

The second point is that teachers' ability to teach VI students needs to be improved. All participants agreed that the teachers had a positive attitude toward learning mathematics. However, on several occasions, the teacher had difficulty explaining graphics-related materials, including making mathematics

more straightforward. S4 revealed, ”Teachers sometimes find difficulties explaining mathematical figures or graphics in simple language”. S6 revealed, ”Teachers need to be able to provide appropriate support. Sometimes teachers assist even though VI students don’t need help. This has a negative impact on us because we become dependent”. This indicates the importance of teachers providing appropriate scaffolding in DMI for VI students.

The third aspect is class management. All participants agreed that they were happy with the mathematics learning environment, but, nevertheless, some of them gave several opinions, such as S6, who explained, ”There is something that still lacks, for example, students with disabilities seated with other disabled. It will have a negative effect because they have difficulties discussing the materials they do not understand, especially if the images are used. Besides that, one non-disabled friend will help one to four children with disabilities. The position where they sit should be mixed with non-disabled friends so that they can improve their social interaction”. Meanwhile, S3 stated, “Hopefully, the discipline can be improved so that the learning process can be better”. This is based on the fact that some students make noise when completing math tasks or projects in the class.

Discussion

This study describes VI students’ voices about DMI in inclusive classes. This can be a starting point for future educational development (Skerritt et al., 2021). Students’ voices must be considered when developing learning practices, and be sensitive to the local context (Pearce & Wood, 2019). Every student has unique backgrounds, personal designs, and aptitudes for learning in an educational environment. Even if they are the same age and gender, they have different learning styles (Tomlinson, 2001). Hence, the teacher must facilitate their uniqueness, for instance, by designing learning materials appropriate to student’s needs to motivate them to participate in class (Baines & Slutsky, 2009). The interview results show that VI students understood their best learning style for mathematics, and DI allows them to learn according to their needs. It is beneficial because they can improve their competence by knowing their learning styles (Bosman & Schulze, 2018).

These findings show that VI students refused content differentiation when learning mathematics. They said that they have the same cognitive abilities as their sighted peers. In addition, giving them the same content shows equality between VI and their sighted peers. VI students explain that they can learn mathematics well through detailed explanations from the teacher and hands-on activities. The aforementioned activities are important because many visual concepts in mathematics are difficult for VI students to comprehend (Sahin & Yorek, 2009). In addition, hands-on activities provide opportunities for VI

students to explore real objects to develop conceptual understanding (Kizilaslan et al., 2021). Also, they can improve learning and achievement in mathematics not only for VI students but also for general students (Savelsbergh et al., 2016). Sighted students can involve more senses through hands-on activities, so that the brain's ability can process information optimally.

In-depth interviews showed that all participants felt comfortable learning mathematics. One of the reasons is that teachers have shown a positive attitude toward learning mathematics in inclusive classes. Teachers can provide good responses and positive attitudes to each student, especially VI students, because learning is differentiated according to their needs. In some parts of the lesson, the teacher also provides an individual approach to assisting VI students. Previous research has proven that teachers are the main factors in implementing inclusive education (Avramidis & Norwich, 2002; Loreman et al., 2013; Specht et al., 2016).

The joyful differentiated mathematics class is not only affected by the teacher's positive attitude but also by students' positive attitude. VI students explained that teachers and their friends often give positive affirmations such as "You can solve this problem" or "It is easy, let's finish it". These findings indicate that sighted students in inclusive classes must have the awareness to be able to communicate and help VI students. In group activities, VI students must be encouraged to take part in completing the tasks. Meanwhile, if they face barriers, sighted students can assist as needed.

During interviews, VI students revealed that they could learn better because mathematics learning was suitable to their needs. They feel more confident and comfortable learning mathematics because the teacher's scaffolding and guidance suit their needs, especially when providing individual assistance. This is predicted to make DI effective in improving students' mathematical abilities. As effective learning, DI ensures equity and fairness in educational practice (Lindner & Schwab, 2020; Valiandes & Neophytou, 2018). This effective learning has a positive impact on student progress and motivation.

The first finding related to improving the quality of differentiated mathematics instruction is providing learning media used for a hands-on activity for VI students. This media is necessary for understanding the concept of graphics and other visual materials. Through the media used for hands-on activities, VI students will learn more actively and involve more senses in the learning process. By using them, the brain's ability will work optimally because other senses are involved (Shams & Seitz, 2008). The existence of multisensory media is useful for VI students and their sighted peers in inclusive classes (Hayes & Proulx, 2023) for developing collaboration between them because sighted students can easily communicate and assist VI students through this media.

The availability of mathematics learning media for hands-on activities can make math lessons more accessible to VI students. The availability of this

media is also a form of equity for VI students to engage in mathematics. In DI, this media becomes an important part of the accommodation, modification, assistive technology efforts, and instructional support. An important aspect to consider in designing and developing learning media to increase VI students' active participation in learning mathematics is to enable close collaboration between teachers, students, parents, and experts in the field (Kizilaslan et al., 2021). It is also important to consider the materials that should be taught using media. In addition, mapping also determines what materials can be taught using the same media. Some adaptations to the activities and teaching approaches outlined in the learning media must be made so that the learning needs of VI students can be met and the material is delivered optimally. Therefore, close collaboration with experts to develop sustainable solutions for teaching and learning mathematics for VI students is essential.

Increasing the teachers' competencies to teach mathematics in inclusive classrooms also needs to be conducted consistently and continuously. This is a response to some of the barriers experienced by VI students when they were learning mathematics. This capability includes classroom management so VI and sighted students can learn optimally. Classroom management is the teachers' competence to create and maintain optimal learning conditions so that learning activities can take place as expected. Previous study emphasizes the positive impact of well-managed classrooms on student engagement, academic performance, and socio-emotional development (Li et al., 2023). Managing the classroom is part of creating a conducive climate for students to fully engage in learning, engage voluntarily, or work on more challenging tasks. This finding aligns with several previous studies recommending that teachers receive training to equip students with knowledge and teaching skills (Hayes & Proulx, 2023; Maguvhe, 2015). This condition is strengthened by the fact that in Indonesia, the majority of mathematics teachers who teach in inclusive classes do not receive an inclusive education curriculum during their undergraduate studies.

Conclusion

This phenomenological study explores VI students' perceptions and understanding of differentiated mathematics instruction in an inclusive class. VI students identified differentiated mathematics instruction, even though it was simpler. They feel that good mathematics learning is through detailed explanations from the teacher and hands-on activities. In inclusive classes, VI students need process differentiation but do not need content differentiation. Several things that must be considered in learning differentiated mathematics in the classroom, from the perspective of VI student, are 1) using the learning media that can help understand graphics-related material, 2) the teacher's ability to explain graphics-related material, including making mathematics simpler,

and 3) conditioning of the learning environment to ensure class safety and VI students sitting next to sighted peers.

Today's teachers must be future-oriented and improve learning and curricula that focus more on individual needs. The education system must accommodate the needs of VI and adjust accordingly to provide better educational services for students. Future research is expected to reveal the perspectives of VI students at lower levels (elementary and junior high schools) and university levels. This is expected to provide a more comprehensive picture, making learning mathematics more accessible to VI students. In addition, future studies should explore students' perspectives on other problems related to mathematics learning. This will create more inclusive mathematics learning practices.

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Glas učenika sa oštećenjem vida: Instrukcije iz diferencirane nastave matematike na inkluzivnom času

Sumbaji Putranto[a, b], Marsigita[a], Elly Arliani[a]

[a] *Univerzitet Negeri Džogdžakarta, Fakultet matematike i prirodnih nauka, Džogdžakarta, Indonezija*
[b] *Univerzitet Islam Negeri Sunan Kalijaga, Fakultet za Tarbiiah i obuku nastavnika, Džogdžakarta, Indonezija*

Uvod: Prethodna istraživanja pokazala su da se inkluzivno obrazovanje suočava sa nekoliko prepreka, posebno među učenicima sa oštećenjem vida (OV), u učenju matematike. Nastavnici mogu da koriste glasove učenika kako bi povećali njihovo angažovanje i pružili im nove perspektive učenja. *Cilj*: Ova studija imala je za cilj da istraži glasove učenika sa oštećenjem vida (OV) o diferenciranoj nastavi matematike u inkluzivnim odeljenjima. *Metod*: Istraživanje je fenomenološko, sa intervjuima kao ključnim elementom u prikupljanju podataka. Učesnici su odabrani korišćenjem namenskog uzorkovanja, a uzorak su činili četiri slabovida učenika i šest slepih učenika starosti 16–18 godina. Podaci su analizirani kroz redukciju podataka, njihovu prezentaciju i izvođenje zaključaka. *Rezultati*: Rezultati su pokazali da učenici sa OV razumeju pojam diferencirane nastave (DN). Oni su tvrdili da dobro učenje matematike postižu kroz detaljna objašnjenja nastavnika i praktične aktivnosti. Učenicima sa OV potrebna je diferencijacija procesa, ali im nije potrebna diferencijacija sadržaja. Nekoliko stvari koje se moraju uzeti u obzir u diferenciranoj nastavi iz matematike su: 1) učenje o medijumima koje može pomoći u razumevanju materijala koji se odnosi na grafičke prikaze, 2) sposobnost nastavnika da objasni materijal koji se odnosi na grafičke prikaze, uključujući i pojednostavljenje matematičkih sadržaja i 3) uslovljenost okruženja za učenje radi obezbeđenja bezbednosti na času i adekvatnog mesta u razredu na kojem učenici sa OV sede, poželjno pored vršnjaka koji vide. *Zaključak*: Nalazi potvrđuju zaključke nekoliko prethodnih studija da učenici sa OV pokazuju visoku samoefikasnost u diferenciranoj nastavi matematike. To pokazuje da učenici imaju poverenje u svoje sposobnosti, tako da ne zahtevaju diferencijaciju sadržaja. Dobijeni nalazi takođe potvrđuju rezultate prethodnih istraživanja u kojima je istaknuta potreba za korišćenjem medijuma za učenje i praktičnih aktivnosti za učenike sa OV.

Ključne reči: glas učenika, oštećenje vida, diferencirana nastava, inkluzivno odeljenje, matematika

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