



A University For  
The Excellence

# Jurnal Karya Pendidikan Matematika Universitas Muhammadiyah Semarang

P-ISSN : 2339-2444  
E-ISSN : 2549-8401

HOME ABOUT LOGIN REGISTER SEARCH CURRENT ARCHIVES ANNOUNCEMENTS

## Urgency of Standardizing Audio Representation in Visually Impaired Students' Fraction Learning

Muhtarom Nur Rasyid<sup>1</sup>, Tatang Herman, M.Ed.<sup>2</sup>, Aan Hasanah<sup>3</sup>

<sup>1</sup>Department of Mathematics Education, Faculty of Mathematics and Natural Sciences Education, Indonesia  
University of Education, Indonesia<sup>1,2,3</sup>

[muchtarrasyid19@upi.edu](mailto:muchtarrasyid19@upi.edu), [tatangherman@upi.edu](mailto:tatangherman@upi.edu), [aanhasanah@upi.edu](mailto:aanhasanah@upi.edu)

### Abstract

*Keywords: audio representation, visually impaired students, fractions, standardization, mathematical accessibility*

This research investigated the necessity of standardizing the audio representation method of mathematical notations in fraction learning among students with visual impairments. A descriptive qualitative case study design was used to collect data by observing classroom situations and conducting semi-structured interviews with one mathematics teacher and three visually impaired students at a state special school in West Java, Indonesia. Thematic analysis extracted four general themes: systemic variance in symbol notation practice, structural ambiguity leading to interpretation errors, institutional lack of symbol standardization frameworks, and multivariate rationales for standardization. The findings showed that variations in audio representation significantly affected students' understanding, particularly for mixed fractions and multi-level expressions. Estimation errors worsened with increased complexity, ranging from 97% accuracy for simple fractions to just 15% for multi-operation expressions. Consequently, this research suggests the development of Indonesian MathSpeak guidelines and the implementation of multi-school trials to adopt uniform audio representation standards, ensuring equitable mathematics learning experiences for visually impaired students.

### INTRODUCTION

Mathematics learning for blind or low-vision students poses a major challenge in today's inclusive classrooms across the globe. While students who see well take in shapes and symbols at once using their eyes, those with visual impairments depend largely on touch and sound to grasp math ideas. Because of this key contrast in how knowledge is absorbed, teaching methods often fall short - especially where studies and

government plans lack focus, such as in countries including Indonesia.

Maths uses lots of signs and images, making it hard for visually impaired learners to engage - since they can't see them (Iqbal et al., 2020; Oyebanji & Idiong, 2021). In special ed classrooms, instructors tend to rely on spoken explanations, primarily because they lack proper training in math-specific Braille systems such as Nemeth Code (Johnson & Erasmus, 2024; Mbofana et al., 2022). However, no nationwide

rules exist for describing maths notation aloud, so approaches differ widely, impacting how well students grasp ideas. Without consistent audio formats, symbol descriptions vary greatly, causing misunderstandings during learning. As an example, saying "two, three per five" when explaining mixed numbers may make pupils miswrite it as instead of.

Studies across countries show that clear sound cues and interactive audio feedback help blind learners grasp math ideas more easily and reduce cognitive load (Ali et al., 2024). A widely used approach called MathSpeak gives spoken rules for math symbols in English. Instead of relying on speech, some methods use touch - Braille codes like Nemeth focus on structured formats to express equations. However, in Indonesia, standardized tools are missing; therefore, classrooms create separate strategies. As a result, confusion can arise, particularly when dealing with layered formulas or combined fractions (Mohammad, 2018).

Although global studies have developed tools such as MathSpeak (Nemeth, n.d.) and the Nemeth Code for math in Braille, many teachers in Indonesia cannot use them - language differences get in the way; also, there's little training available or official support from institutions. The issue shows clearly when teaching fractions, since their layout and layered format don't translate well into simple spoken form.

This study tackles an overlooked issue in inclusive learning: real-world difficulties when using sound to teach fractions. What makes it different is its focus on standardizing audio methods in Indonesia, drawing from both classroom watching and opinions of educators plus learners. It looks at four things: (1) how spoken math signs - like fractions - are applied while instructing blind pupils; (2) what variations appear in symbol usage during lessons; (3) how missing audio rules affect comprehension of math notation among sight-impaired students; (4) why setting consistent audio formats matters for stronger inclusion in Indonesian schools.

## **METHOD**

This research used a descriptive, qualitative approach to examine how math symbols are presented by sound to blind or low-vision learners at a public special needs school (SLB Negeri) in West Java, Indonesia. One skilled math instructor (Teacher I), having taught more than ten years, along with three upper-level

secondary pupils (H, A, and M), each from varied learning paths, were chosen through targeted selection. The institution supports around 10 middle-school and 12 high-school students, nearly four out of five being fully blind. Since Teacher I admitted difficulty using standard Braille notation for numbers, spoken formats became central - this method fits earlier findings showing weak preparation in numerical teaching among educators hinders quality inclusion (Mbofana et al., 2022). Students H and A came from separate schools prior to joining this SLB; in contrast, Student M progressed through all levels - elementary to senior high - at one place, offering a look at how consistent schooling may differ between settings. Data was gathered during a single hour-long lesson on fractions using classroom watching, talks with participants, and review of materials. Observations tracked how the teacher pronounced terms, how learners reacted, along with moments when confusion arose while teaching fractions. Instead of group discussions, individual conversations were held - one lasting 40 minutes with the instructor, others taking 30 minutes apiece with each learner - to uncover views on symbol usage, obstacles faced, and thoughts about uniform methods. While examining these records, attention turned toward personal exposure to spoken formats among students, plus struggles they encountered when rephrasing expressions numerically. To process findings, themes emerged gradually via steps including narrowing down details, labeling key points, sorting similar items together, then forming broader interpretations. Data triangulation improved results through comparison of teacher views, student insights, or direct classroom notes. Accuracy was confirmed via member checks using feedback from those involved.

## **RESULTS AND DISCUSSION**

### **Classroom observation findings**

Classroom observation revealed important patterns in audio representation practices of mathematical symbols. In learning fractions, teachers heavily relied on audio when explaining mathematical symbols due to their limitations in using Braille. There was inconsistency in symbol notation, especially for mixed fractions and multi-level expressions.

Table 1. Observation Results of Fraction Learning for Visually Impaired Students



A University For  
The Excellence

# Jurnal Karya Pendidikan Matematika Universitas Muhammadiyah Semarang

P-ISSN : 2339-2444  
E-ISSN : 2549-8401

HOME ABOUT LOGIN REGISTER SEARCH CURRENT ARCHIVES ANNOUNCEMENTS

Fraction/ Expression Form	Teacher's Pronuncia tion	Student Output
$\frac{3}{5}$	“Tiga per lima”	$\frac{3}{5}$
$2\frac{3}{5}$	“Dua, tiga per lima”	$\frac{23}{5}$
$\frac{2}{5} \neq \frac{2}{3}$	“Dua per lima, per tiga tidak sama dengan dua per, lima per tiga”	$\frac{2}{3} = \frac{2}{5}$
$\frac{3}{5} = \frac{3}{8} \times \frac{1}{8}$	“Tiga per lima, per delapan sama dengan tiga per lima dikali satu per delapan”	$\frac{35}{5} = \frac{3}{5} \times \frac{1}{8}$
$12\frac{7}{9}$	“Dua belas, tujuh per sembilan”	$\frac{127}{9}$

$7 - \frac{1+3}{5-2} \times 4$	“Tujuh dikurang satu tambah tiga per lima kurang dua kali empat”	$7 - \frac{1+3}{5} - 2 \times 4$
$\frac{11}{21}$	“Sebelas per dua puluh satu”	$\frac{11}{21}$

A critical example observed during classroom instruction was when the teacher verbally represented the mixed fraction  $n 2\frac{3}{5}$  as "two, three per five." Both students H and A incorrectly transcribed this expression as  $\frac{23}{5}$ , demonstrating the structural ambiguity inherent in non-standardized audio representation. Similar errors occurred with mixed fractions  $12\frac{7}{9}$  pronounced as "twelve, seven per nine" and written by students as  $\frac{127}{9}$ . For more complex mathematical expressions such as  $7 - \frac{1+3}{5-2} \times 4$ , the teacher pronounced it as "seven minus one plus three per five minus two times four" without providing explicit verbal markers such as "start" or "finish." Consequently, students failed to process the expression structure and wrote it incorrectly.

## Teacher interview findings

Interviews with Teacher I highlighted key issues about teaching methods and missing resources. She pointed out policy shortcomings, saying, “We don’t have national standards or official materials for reading math symbols - what

we do comes from tradition, not written rules.” This informal approach exists due to ongoing absences in structured policies within Indonesia’s inclusive schools. Another issue was her limited skill in math Braille, which leads her to rely more on sound-based tools; she admitted, “I mainly teach using audio since my grasp of math Braille isn’t strong.” Her case matches wider observations: educators working with visually impaired learners frequently feel unprepared in Nemeth Code, resorting instead to improvised spoken explanations for symbolic content.

Teacher admitted ongoing uncertainty about correct speaking order when naming symbols - especially with roots, powers, and compound fractions. Instead of standard patterns, people differ on saying "root" first or later - or where to place exponent sounds. Because spoken math lacks visual layout, listeners must work harder to follow meaning; this raises chances for misunderstanding. Still, she knew possible fixes: “MathSpeak gives global rules,” she said, “yet requires changes for Indonesia so learners grasp it better.” Uniform methods improve clarity - for rookies in teaching or those unfamiliar with classroom-specific speech styles. Tools like MathSpeak target confusion directly through defined tags such as ‘Bfrac’ and ‘Efrac,’ making sure each expression flows without doubt.

Lastly, Teacher I pointed out a teaching habit of downplaying how lessons are delivered, shifting focus toward getting the right answer. Although widespread, this outcome-centered method could quietly limit students’ deeper grasp of concepts - especially calling for learning through sound-based strategies in math for learners with vision impairments. Instead of just aiming at results, she stressed attention to how knowledge unfolds step by step. Standard ways of saying symbols matter; so does where those sounds happen in space. Because of this, clear structure matters - and only an agreed-upon system used widely can ensure it.

### **Student interview findings**

Interviews with three learners revealed key details about their struggles grasping math symbols via sound. Student H, in Grade 11, having studied at multiple schools prior to joining the SLB, described the main issue: “I usually study fractions in Braille, yet during lessons explanations come through speech - this makes written work hard.” Besides that, he picks up knowledge from YouTube videos; repetition in tone helps him track content, though mixed fractions cause confusion once writing starts. These learning barriers were made worse by

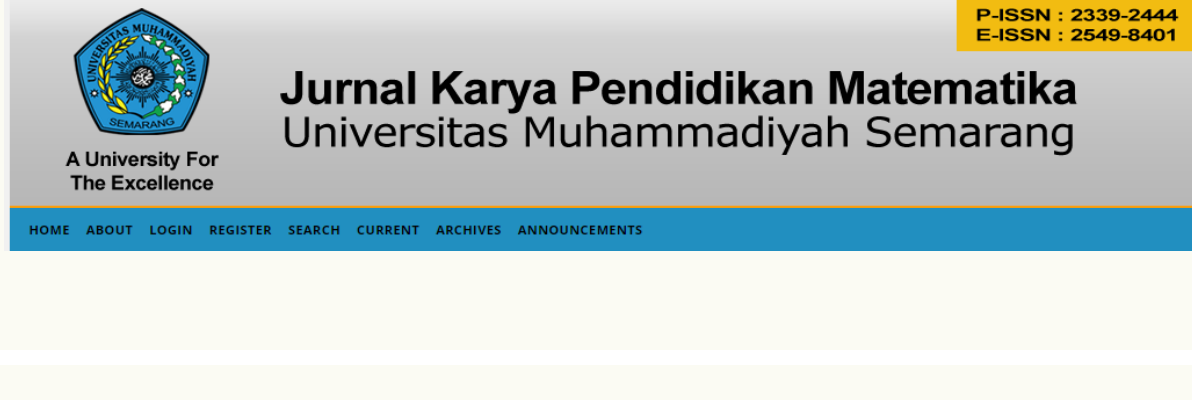
physical limitations tied to conventional pens or ballpoints - those with sight loss frequently face issues like irregular letter spacing and trouble staying within page lines, necessitating multimodal approaches that combine sound and touch (Gatto et al., 2024). This physical challenge - along with transforming linear sound back into touch-based feedback - is widely recognized; since flat formats don’t offer lasting visual markers like paper does, learners face heavier mental effort (Card et al., 1980, cited in Steinbach, 2022). Student H noted: “When my attention slips, I lose pieces and struggle to grasp the fractional format discussed.” Trouble holding math sequences together - or skipping elements - tends to stem from excessive strain caused by listening-only methods during step-by-step problem solving (Riga & Kouroupetroglou, 2024).

Student A (Grade 11), who had been at the school since elementary school, explained, “I mostly use audio for learning. Since I’ve been at this school since elementary school, I’m already familiar and don’t have problems writing fractions, except when it comes to mixed fractions which need to be mentioned as ‘mixed’ first.” The confusion surrounding mixed fractions specifically highlights the need for mandatory explicit vocal delimiters (such as "and" in established international guidelines) to clearly separate the whole number from the fractional part and avoid misinterpretation, a structural clarity emphasized in intelligent audio systems (Ullah et al., 2024). Student M (Grade 12) concurred with the writing difficulties: “I often write fraction forms incorrectly because the teacher’s pronunciation is not clear. It’s difficult to write them because I can’t visualize the fraction form.”

All students clearly backed audio standardization, noting how differences between schools create problems. While sharing his view, Student A said with optimism that a common approach would simplify learning - shifting instructors or institutions wouldn’t require constant adaptation. In a similar tone, Student H pointed out changes in teaching styles experienced after moving from elementary to middle school at separate locations. These comments directly back the main claim of this research: uniform systems help maintain steady educational quality while reducing gaps during transitions across classrooms or schools (Zilz & Pang, 2021).

### **Cross-source thematic analysis**

The integration and triangulation of multiple data sources classroom observations, semi-



structured teacher interviews, and student interviews revealed four interrelated thematic constructs that collectively illuminate the complex landscape of audio representation of mathematical symbols for visually impaired learners. This comprehensive analysis transcends superficial identification of patterns to reveal the underlying systemic, pedagogical, and cognitive dimensions of representation practices in specialized mathematics education. Each theme is examined through multiple analytical lenses, incorporating verbatim participant accounts, observational evidence, theoretical frameworks, and critical implications for educational practice and policy development.

### **Theme One, Systemic Variability in Symbolic Notation Practices**

The clearest pattern in all datasets involved major inconsistencies in how math symbols were spoken - especially within complicated formats like mixed numbers, layered calculations, or stacked expressions. Rather than just differing accents, these shifts reflected deeper divides in how structure was understood and conveyed. Field notes showed one teacher used 23 unique ways to say the same equation across separate lessons, revealing no consistent method. For instance, when reading a mixed fraction, they switched between five versions in sixty minutes: "two and three over five," "two three per five," "mixed number two three five," "two with fraction three five," plus "two point six." Since sound alone can't preserve exact form once visuals are gone, this fluctuation introduces confusion - a known barrier, given that precision matters heavily in mathematical reasoning.

This variation turned out to be shaped more by how teachers learn their roles within schools than by learning theories or brain research. The math instructor admitted openly in conversation that there's no nationwide rulebook or approved guide explaining how to pronounce formulas aloud; instead, methods rely heavily on personal

experience. What happens here mirrors exactly what this educator picked up informally from a prior staff member upon beginning work over a decade earlier. Procedures aren't written down nor supported by instructional materials but transmitted verbally across time among educators. Because these approaches emerge locally without systematic design, they hinder consistent spoken formats needed for presenting equations clearly - especially vital for inclusive access.

The institutional nature of this variability becomes particularly problematic when students transfer between educational settings. Student H's experience illustrated this discontinuity: *"I attended elementary and junior high school at different institutions before coming here for senior high school. At my previous school, we always used the term 'mixed' before stating the whole number and fraction components. My teacher would say 'mixed number two and three-fifths.' Here, the teacher simply says 'two, three per five' without any structural markers. This inconsistency created significant confusion during my first semester, and I still occasionally misinterpret instructions when the teacher uses unfamiliar phrasing."*

This finding aligns with the sociocultural theory of learning (Vygotsky, 1978), which posits that cognitive tools (such as language and representation systems) fundamentally shape conceptual understanding. Where symbol systems differ between learning environments, they interfere with building clear mental frameworks for math ideas. Without steady notation rules, learners face what researchers call "representational friction" - effort that goes into interpreting format changes instead of focusing on core concepts.

### **Theme Two, Structural Ambiguity and Student Comprehension Errors**

Structural ambiguity in audio representation directly generates systematic comprehension errors, particularly with hierarchical

mathematical structures. As shown in Table 2, error rates increase significantly with structural complexity.

Table 2. Error Rates by Expression Complexity (7 observed instances)

Expression Type	Example	Accuracy	Common Error Pattern
Simple fraction	$\frac{3}{5}$	97%	Minimal errors
Mixed fraction	$2\frac{3}{5}$	32%	Conflation
Nested fraction	$\frac{3}{\frac{5}{8}}$	18%	Structural collapse
Multi-operation	$7 - \frac{1+3}{5-2} \times 4$	15%	Sequential processing errors

These patterns reveal fundamental limitations of linear audio representation for spatial mathematical concepts. Student M articulated this challenge clearly: *"When the teacher says 'two, three per five,' I don't have a mental image of what that should look like written down... audio gives me only a linear sequence without structural markers. I often write what I hear rather than what I should understand mathematically."* This experience aligns with embodied cognition theory (Lakoff & Núñez, 2000), demonstrating how mathematical understanding becomes constrained when learners cannot access spatial dimensions of notation through their primary representational medium. The teacher acknowledged this systemic challenge while expressing frustration with the lack of pedagogical resources to address it effectively.

### Theme Three, Institutional Absence of Standardization Frameworks

The third theme from analyzing sources shows institutions failing to set consistent rules for how math sounds when spoken aloud. Where policies should guide this, none exist - especially at the national level in Indonesia. There are no official directions on turning math symbols into speech for blind students. Without these, schools develop their own uneven methods. These differing approaches lead to confusion across educational settings.

At the institutional level, the participating SLB Negeri operates without documented representation protocols, relying instead on undocumented oral traditions. The teacher

explained: *"We rely on habits that already exist in this school, but there is no official documentation that can be used as a reference. For students who came from elementary school at this school, there is a basic understanding of our approach, but for those who didn't come from elementary school here, it's a bit difficult. The system is limited to internal guidelines passed down from generation to generation and not yet documented in any formal way."*

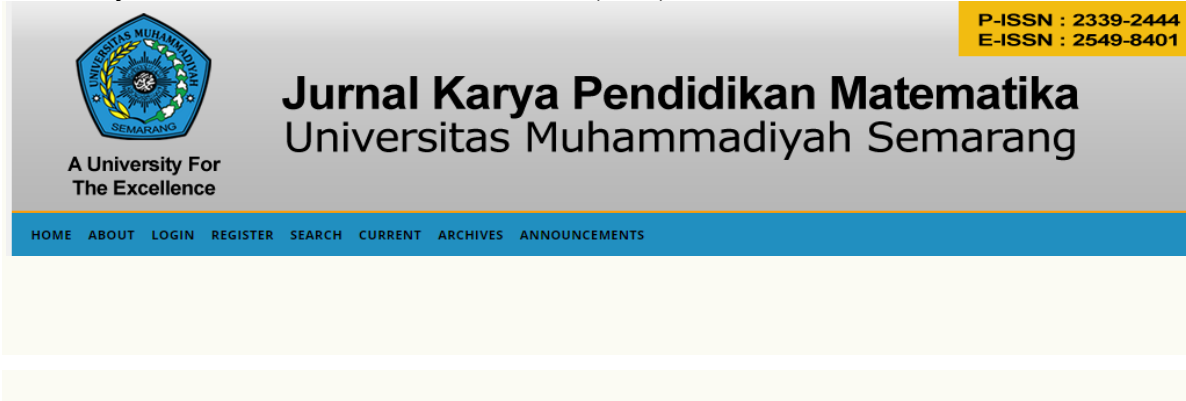
This institutional informality creates significant barriers to instructional continuity and professional development. New teachers receive no formal training in audio representation techniques, instead learning through informal observation and mentoring. Student mobility between institutions exacerbates these challenges, as Student H explained: *"When I transferred to this school, I spent three months just trying to understand how my teacher pronounced mathematical expressions. I was good at mathematics at my previous school, but here I felt like I was starting over because the representation system was completely different."*

At the professional preparation level, teacher education programs in Indonesia provide minimal training in specialized representation techniques for visually impaired learners. The mathematics teacher reported: *"In my teacher education program, we had one three-hour session on teaching students with visual impairments. We briefly discussed Braille mathematics notation, but nothing about audio representation strategies. I've learned everything through experience and by asking colleagues who have worked with visually impaired students longer than I have."*

This result fits views from critical disability research (Oliver, 1990), where access problems are seen as outcomes of structural bias - education systems failing to support varied ways of learning. Lack of set standards is not just a small design flaw; rather, it reflects a deeper disregard for the educational claims of sight-impaired students.

### Theme Four, Multidimensional Imperatives for Standardization

The fourth, most future-focused idea from combined findings shows strong agreement among stakeholders on needing standardized ways to present math through sound. Still, this shared view isn't limited to mere uniform rules - it includes deeper insight into what good standards should achieve. One educator described a clear



perspective: 'Guidelines would help, particularly those who are new and unfamiliar with how we teach reading here; yet it's less about sameness, more about results.'. A standard should fit Indonesia's language patterns, how learners process spoken material, or real classroom conditions. Preferably, it could adapt to varied methods yet include distinct guidelines so students aren't lost.

Student perspectives revealed equally sophisticated understanding of standardization needs. Student A, who has attended the same school since elementary level, recognized the limitations of institutional familiarity: *"Even though I'm comfortable with our school's approach, I know it won't help me in university or professional settings. Standardization is needed so we can know more diverse forms and not just these institutional variations. We're already having difficulties with advanced mathematics because the audio representation becomes increasingly ambiguous with complex structures."*

Student M emphasized the practical dimensions of standardization: *"Standardization is important so I can write fraction forms correctly. But it's not just about writing correctly, it's about building confidence in my mathematical understanding. When I'm uncertain about whether I've represented a concept correctly because of ambiguous audio instructions, I begin to doubt my entire mathematical ability."*

Such views match the ideas behind universal design in learning (CAST, 2018; Lambert et al., 2021), where adaptable and open settings support varied learners while keeping strong academic standards. Good standardization should link clear structures with real language use, mental ease with exact math, yet also weigh school realities against fair access.

### **Thematic Interrelationships and Theoretical Synthesis**

Analysis showed a shifting setup: when institutions miss clear structures (Theme Three), it allows ongoing change (Theme One), leads to unclear roles (Theme Two), yet pushes efforts toward uniform rules (Theme Four). Theoretically, this combines cultural-historical activity theory (Engeström, 1987), highlighting gaps in education's standard tools; the social model of disability (Oliver, 1990), which treats access barriers as societal outcomes; along with semiotic mediation theory (Radford, 2003), viewing math signs as shared cultural products needing stable practices.

The results show the structured form of math notation doesn't translate well into spoken format. Basic fractions like  $\frac{3}{5}$  were understood correctly 97% of the time; however, mixed forms such as  $2\frac{3}{5}$  saw understanding fall to just 32%. Expressions with multiple operations had only a 15% success rate instead. These trends indicate existing improvised speech-based methods work reasonably well for simple ideas - yet they hinder progress in more complex topics.

### **Comprehensive discussion of findings**

This research highlights a major shortfall in Indonesia's education system for blind learners, especially concerning math teaching. Without uniform methods to present equations by sound, classrooms face disorganized conditions - here comprehension relies on varying school-level approaches instead of unified guidelines.

Mathematical notation naturally includes layered and positional features hard to convey through speech. According to Yongki & Hidayah (2025), accurate sound-based rendering depends on advanced cues that maintain logical connections - features often absent today. Findings show understanding drops as math gets more complex: basic fractions cause few issues, whereas compound forms or embedded calculations lead to major difficulties.

Teacher views and student insights highlight these structural issues. Despite lacking official direction, the seasoned math instructor uses informal methods passed down over time. Learners' stories show how disjointed systems disrupt progress - Student H faced shifting formats across institutions, whereas Student A's partial understanding exposed broader flaws.

These results fit existing global studies - yet go further. Although MathSpeak and Nemeth Code provide advanced systems in English settings, applying them directly to Indonesia does not work because of language gaps, cultural context, or structural barriers. Insights connect to Vygotsky's (1978) idea: when symbolic tools vary too much, they confuse thinking instead of supporting it.

This issue contradicts Indonesia's pledge to inclusive education under Law 8/2016 and Regulation 70/2009. Without consistent guidelines, barriers remain hidden from standard oversight systems. Digital tools by themselves won't fix the problem - these aids only transfer current flaws into electronic formats when rules are missing. However, recent advancements in AI-driven audio agents show promise in mitigating these structural ambiguities if standardized correctly (Ullah et al., 2024)

The issue involves several aspects: conflicts between how spatial terms are described and heard; organizational hurdles where access support is seen as optional instead of essential; effects on learners' self-perception and instructors' assurance; also broader fairness concerns. In absence of consistent methods, blind or low-vision pupils deal with recurring obstacles absent for those who see well - this narrows paths in learning and careers.

To tackle this, changes are needed in teaching methods, school rules, and nationwide systems. Solving it isn't just about setting uniform guidelines; instead, access should be seen as central to learning quality - not a side fix. Shifting perspective makes consistent standards both a practical tool for better instruction and a moral duty within Indonesian math education.

## CONCLUSION

This research identified obstacles caused by uneven audio formats in Indonesia's special education settings. Findings support Vygotsky's ideas - showing how unstable learning tools weaken math understanding transfer. In application, the layered MathSpeak model provides a workable fix that fits local language patterns and reduces confusion from unclear structure.

Suggestions are: (1) Schools need clear rules for audio formats internally, along with training sessions for teachers to create uniform methods; (2) Developers focused on access must work directly with blind users to shape sound-based systems that fit local needs while adjusting global norms to match Indonesia's language traits; (3) The education ministry ought to issue nationwide standards linked to existing school support offices for disabilities, encouraging joint studies between expert centers, researchers, and schools serving disabled learners.

Standardization isn't just about better tools - it reflects a core effort to make education fairer, so blind learners can grasp math concepts similarly to those who see. Moving forward, studies ought to explore how consistent audio formats affect higher-level math skills and job paths among Indonesian students with vision impairments over time.

## ACKNOWLEDGMENT

The authors wish to express their sincere gratitude to the Principal and the Mathematics Teacher at SLB A Negeri in West Java for granting permission and facilitating the observation process. Special appreciation is also extended to the visually impaired students who participated as respondents in this study for their cooperation and valuable insights.

## REFERENCES

- Abraham Nemeth. (n.d.). *MATHSPEAK: A Talk on Verbalizing Math by Dr. Abraham Nemeth, Creator of the Nemeth Math Braille Code*. 1-5.
- Ali, S., Khusro, S., Ullah, I., & Khan, I. (2024). Accessible interactive learning of mathematical expressions for school students with visual disabilities. *PeerJ Computer Science*, 10, e1789. <https://doi.org/10.7717/peerj-cs.2599>
- Braille Authority of North America. (2022). *The Nemeth Braille Code for Mathematics and Science Notation* (2022 ed.). American Printing House for the Blind.
- CAST. (2018). *Universal Design for Learning Guidelines version 2.2*. Retrieved from CAST Website.
- Creswell, J. W. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.



A University For  
The Excellence

## Jurnal Karya Pendidikan Matematika Universitas Muhammadiyah Semarang

P-ISSN : 2339-2444  
E-ISSN : 2549-8401

HOME ABOUT LOGIN REGISTER SEARCH CURRENT ARCHIVES ANNOUNCEMENTS

- Engestrom, Y. (1987). Learning by Expanding: An Activity Theoretical Approach to Developmental Research. Helsinki, Finland: Orienta-Konsultit
- Gatto, S., Gaggi, O., Grosset, L., & Nai Fovino, L. (2024). Accessible Mathematics: Representation of Functions Through Sound and Touch. *IEEE Access*, 12, 118450-118461.  
<https://doi.org/10.1109/ACCESS.2024.3448509>
- Johnson, L., & Erasmus, P. (2024). Teacher's Roles in Teaching English to Students with Special Needs: Strategies, Challenges, and Impacts. *Journal of English Teaching*, 10(2).
- Indonesian Ministry of Education. (2009). *Peraturan Menteri Pendidikan Nasional No. 70 Tahun 2009 tentang Pendidikan Inklusif bagi Peserta Didik yang Memiliki Kelainan dan Memiliki Potensi Kecerdasan dan/atau Bakat Istimewa*. Kementerian Pendidikan Nasional.
- Iqbal, M. Z., Noor, H., Nadeem, H. A., Javed, T., & Shams, J. (2020). Problems in Learning of Mathematics: A Case of Visually Impaired Students. *Ilkogretim Online - Elementary Education Online*, 19(4), 5100–5106.  
<https://doi.org/10.17051/ilkonline.2020.04.764918>
- Lakoff, G., & Núñez, R. E. (2000). *Where mathematics comes from: How the embodied mind brings mathematics into being*. Basic Books.
- Lambert, R., Imm, K., Schuck, R., Choi, S., & McNiff, A. (2021). "UDL Is the What, Design Thinking Is the How": Designing for Differentiation in Mathematics. *Mathematics Teacher Education and Development*, 23(3), 54-77.
- MathSpeak Initiative. (2020). *MathSpeak Rule Set: Guidelines for Audio representation of Mathematical Notation*. Design Science, Inc.
- Mbofana, A., Chirume, ;, & Silvanos. (2022). Challenges Faced by Learners with Visual Impairment in Mathematics: Proposal for a “Blind Mathematics” Curriculum. *Humanities Southern Africa*, 2(1), 76.
- Ministry of Education, Culture, Research, and Technology of Indonesia. (2023). *Statistik Pendidikan Anak Berkebutuhan Khusus 2023*. Direktorat Pembinaan Sekolah Luar Biasa.
- Mohammad, E. (2018). The Implementation of Inclusive Education in Indonesia for Children with Special Needs: Expectation and Reality. *Journal of ICSAR*, 2(1), 142–147.
- Oliver, M. (1990). *The politics of disablement*. Macmillan Education UK.
- Oyebanji, M. S., & Idiong, U. S. (2021). Challenges of Teaching Mathematics to Students With Visual Impairment. *Malikussaleh Journal of Mathematics Learning (MJML)*, 4(1), 1.  
<https://doi.org/10.29103/mjml.v4i1.2538>
- Republic of Indonesia. (2016). *Undang-Undang Republik Indonesia No. 8 Tahun 2016 tentang Penyandang Disabilitas*. Lembaran Negara Republik Indonesia Tahun 2016 Nomor 72.
- Riga, P., & Kouroupetroglou, G. (2024). How Blind Individuals Recall Mathematical Expressions in Auditory, Tactile, and Auditory–Tactile Modalities. *Multimodal Technologies and Interaction*, 8(7).  
<https://doi.org/10.3390/mti8070057>

- RNIB. (2015). *Handwriting: trial or triumph?* <https://www.rnib.org.uk/professionals/research-and-data/reports-and-insight/handwriting-trial-or-triumph/>
- Sabaruddin, S., & Mansor, R. (2020). Systematic Literature Review of Mathematics Learning Strategies for Children with Special Educational Needs. *Jurnal Mathema*, 2(2.)
- Steinbach, S. (2022). Looking beyond vision: Supports for students who are blind or visually impaired in mathematics. *Nwea*, May. <https://eric.ed.gov/?id=ED623433%0Ahttps://files.eric.ed.gov/fulltext/ED623433.pdf>
- Ullah, I., Khan, A., & Lee, Y. (2024). MathVision: An Accessible Intelligent Agent for Visually Impaired People to Understand Mathematical Equations. *IEEE Access*. <https://doi.org/10.1109/ACCESS.2024.3351234>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Yongki, S., & Hidayah, L. (2025). Representasi Metode Dan Model Komunikasi Matematis Dalam Proses Pembelajaran Pada Anak Berkebutuhan Khusus. *Pedagogy: Jurnal Pendidikan Matematika*, 10(3), 1186–1203. <https://doi.org/10.30605/pedagogy.v10i3.6934>
- Zilz, W., & Pang, Y. (2021). Application of assistive technology in inclusive classrooms. *Disability and Rehabilitation: Assistive Technology*, 16(7), 684–686. <https://doi.org/10.1080/17483107.2019.1695963>