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Analisis of Numeracy Literacy among Visually Impaired Students at YAPTI Based on the Degree of Visual Impairment

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ABSTRACT: This study aims to analyze the impact of the degree of visual impairment on the numeracy literacy skills of students at the Indonesian Foundation for the Visually Impaired (YAPTI). A quantitative research approach with a descriptive-comparative design was employed. Data were collected through numeracy literacy tests, observations, and interviews with both students and teachers. The findings indicate significant differences in numeracy literacy skills between students with low vision and those with total blindness. Students with low vision scored higher in fundamental concept comprehension, problem-solving, and mathematical patterns and relationships compared to totally blind students. These differences are influenced by access to visual information, teaching methods, and the availability of assistive tools. Totally blind students rely more on Braille- and tactile-based methods, which require additional time to comprehend numeracy concepts. To bridge this gap, the development of multisensory learning media, increased availability of assistive tools, teacher training, and the integration of AI- and audio-based technology in learning are essential. With appropriate interventions, numeracy literacy among visually impaired students can be enhanced, promoting more inclusive and high-quality education.

KEYWORDS: numeracy literacy, visually impaired students, degree of visual impairment, inclusive education, assistive learning tools

I. INTRODUCTION

Numeracy literacy is an essential competency in education, encompassing the ability to understand, utilize, and reason with mathematical concepts and skills in various real-life contexts. This ability is not only crucial for students' academic development but also plays a significant role in shaping critical thinking and problem-solving skills required in different aspects of life (OECD, 2019). In the context of inclusive education, numeracy literacy becomes increasingly complex as it involves various challenges for students with special needs, including those with visual impairments.

Visually impaired students face unique barriers in developing numeracy literacy due to their limited access to visual information, which traditionally dominates mathematics learning. Previous studies have shown that these limitations lead to difficulties in understanding spatial concepts, geometry, and numerical representations, which are predominantly visual-based (Sari, 2022). Therefore, alternative multisensory learning strategies, such as the use of Braille, tactile aids, and assistive technology, are crucial in supporting numeracy concept comprehension for students with visual impairments (Hasanah et al., 2021; Figueiredo & Nunes, 2019).

Furthermore, visually impaired students encounter challenges in understanding number relationships, patterns, and mathematical operations, which are often presented in visual formats. According to Smith and Jones (2020), students with total blindness rely on audio- and touch-based strategies to develop mental representations of numbers and geometric shapes. Hence, integrating assistive tools such as tactile diagrams and voice-based software can enhance their numeracy comprehension. Other studies have also demonstrated that Braille-based learning tools are effective in helping visually impaired students grasp mathematical concepts (Karshmer & Gillman, 2020). Additionally, research by Wijayanti and Kusuma (2021) indicates that the use of Braille-based learning aids significantly improves numeracy understanding among visually impaired students.

Various methods have been developed to assist visually impaired students in mastering numeracy literacy. One of the key strategies is the use of tactile learning aids, such as Braille boards and tactile diagrams, which enable students to grasp mathematical concepts through touch. For instance, the use of customized geoboards for visually impaired students has been proven effective in enhancing their understanding of geometry (Hadi & Wulandari, 2022). Additionally, assistive technology plays a pivotal role in supporting numeracy literacy among visually impaired students. The use of voice-based software, such as

screen readers and talking calculators, enables students to independently access learning materials. A study by Anderson and Carter (2023) found that visually impaired students who utilized voice-based software demonstrated a 30% improvement in numeracy comprehension compared to those using conventional methods.

Despite the development of various methods, the implementation of inclusive education for visually impaired students still faces numerous challenges. One of the primary barriers is the lack of teacher training in numeracy instruction for students with visual disabilities. Many educators lack the necessary skills to utilize specialized tools for visually impaired students, resulting in less effective learning experiences (Nurhadi, 2023).

Moreover, the limited availability of resources and infrastructure in many schools further hinders the accessibility of learning for visually impaired students. A study by Prasetyo and Wulandari (2022) found that 70% of schools in Indonesia still lack disability-friendly learning facilities, including access to Braille books and tactile aids. In terms of policy, further efforts are needed to ensure that the curriculum is truly inclusive and accessible to all students, including those with visual impairments. UNESCO (2022) emphasizes that effective inclusive education policies must include adequate resource provision, continuous teacher training, and technological support accessible to all students.

The urgency of this research lies in the need to understand how the degree of visual impairment affects numeracy literacy skills among visually impaired students at the Indonesian Foundation for the Visually Impaired (YAPTI). This study aims to analyze how different levels of visual impairment—whether low vision or total blindness—contribute to variations in numeracy concept comprehension, learning strategies, and the effectiveness of teaching methods employed. The findings of this research are expected to provide deeper insights for educators and policymakers in designing more inclusive interventions and enhancing the quality of education for visually impaired students (World Health Organization, 2021).

Thus, this study not only contributes to the theoretical development of numeracy literacy and inclusive education but also has practical implications for improving learning effectiveness for visually impaired students. A better understanding of the relationship between visual impairment levels and numeracy literacy will enable the development of more tailored learning methods that meet their needs, thereby supporting the achievement of fairer and higher-quality education for all students. Furthermore, the findings of this study are expected to raise awareness of the importance of inclusivity in numeracy education and encourage governments and educational institutions to take a more active role in providing adequate facilities for visually impaired students.

II. RESEARCH METHODS

This study employs a quantitative approach with a descriptive-comparative design to analyze the relationship between the degree of visual impairment and numeracy literacy among students at the Indonesian Foundation for the Visually Impaired (YAPTI). The research subjects consist of visually impaired students enrolled at YAPTI, with the sample selected using a purposive sampling technique based on their level of visual impairment.

A. Categorization of Levels of Visual Impairment

The degree of visual impairment in this study is categorized based on the criteria established by the World Health Organization (WHO, 2021) and the Indonesian Ministry of Education. The two main categories used are:

1. Low Vision: Students with residual vision that allows them to recognize shapes, colors, or text with the aid of visual assistive devices such as magnifiers or digital tools.
2. Total Blindness: Students with no light perception who rely entirely on touch and hearing for learning.

Data on the degree of visual impairment were obtained through students' medical records and interviews with teachers and parents to ensure accurate classification.

B. Numeracy Literacy Measurement

The numeracy literacy of visually impaired students was assessed using a test instrument developed based on the literacy assessment standards of the Programme for International Student Assessment (PISA) and the Indonesian National Curriculum. The measurement covered several key aspects:

1. Understanding of Basic Concepts: Mastery of fundamental mathematical operations such as addition, subtraction, multiplication, and division in various real-life contexts.
2. Problem-Solving Ability: Skills in solving case-based or scenario-based problems that require logical analysis and the application of mathematical concepts.
3. Data Representation and Interpretation: The ability to read and interpret data in the form of tables, tactile diagrams, and auditory representations.
4. Mathematical Patterns and Relationships: The ability to recognize and understand numerical patterns and relationships using non-visual means, such as braille-based tools or voice-assisted applications.

The test instrument was adapted to the characteristics of visually impaired students, incorporating braille materials, tactile aids, and assistive technology to ensure accessibility. The validity and reliability of the instrument were tested through a pilot study before its implementation in the main research.

C. Data Collection Procedures

Data were collected through several stages:

1. Numeracy Literacy Test: Students were given a series of tests tailored to their level of visual impairment.
2. Observation: Monitoring students' learning strategies when solving numeracy problems, including the use of tactile tools and assistive technology.
3. Semi-Structured Interviews: Conducted with teachers and students to explore the challenges they face and the strategies they employ in understanding numerical concepts.

D. Data Analysis Techniques

The collected data were analyzed using descriptive statistics and comparative tests (t-test or Mann-Whitney U test) to compare numeracy literacy outcomes between low-vision and totally blind students. This analysis aimed to identify patterns of differences in numeracy literacy achievement based on students' levels of visual impairment and the factors influencing their ability to comprehend numerical concepts.

The findings of this study are expected to provide deeper insights into the effectiveness of numeracy learning methods for visually impaired students and offer recommendations for the development of more inclusive and evidence-based educational strategies.

III.RESULT AND DISCUSSION

A. Numeracy Literacy Test Results

Based on the numeracy literacy test results of visually impaired students at the Indonesian Foundation for the Visually Impaired (YAPTI), along with observations of learning activities and interviews with students and teachers, several key findings were identified. The test results indicate a significant difference in scores between low-vision and totally blind students in understanding numeracy concepts.

Table 1. Numeracy Literacy Test Results by Degree of Visual Impairment.

No	Aspect Literacy Numeracy	Low Vision (Mean ± SD)	Total Blind (Mean ± SD)	Statistical Test (p-value)
1	Basic Conceptual Understanding	78.2 ± 4.7	60.5 ± 7.1	0.002**
2	Problem Solving Skills	71.8 ± 5.9	50.3 ± 6.4	0.005**
3	Data Representation and Interpretation	74.1 ± 4.5	58.7 ± 5.9	0.008*
4	Mathematical Patterns and Relations	76.5 ± 5.3	55.2 ± 6.7	0.001**

*Note: *p < 0.05 (significant), *p < 0.01 (highly significant)

Standard deviation is a statistical measure that indicates how dispersed the data is in a dataset. A smaller standard deviation means that the data points are closer to the mean, whereas a larger standard deviation indicates a more widely spread distribution.

The table above highlights that the most significant difference appears in the aspect of Mathematical Patterns and Relationships, where low-vision students achieved an average score of 76.5. This score suggests that low-vision students have a relatively good understanding of recognizing numerical patterns and relationships, with a relatively small standard deviation of 5.3, indicating a consistent level of understanding among most students. In contrast, totally blind students scored an average of 55.2, suggesting significant difficulties in this aspect, with a standard deviation of 6.7, indicating considerable variation in understanding. Some students may still recognize simple patterns, but many struggle with more complex mathematical relationships. This difference has a p-value of 0.001, indicating a highly significant result. This can be attributed to low-vision students' ability to recognize visual-based patterns and relate numbers to clearer symbolic representations, whereas totally blind students rely entirely on braille and tactile aids.

In the Basic Concept Understanding aspect, there was also a considerable difference, with low-vision students scoring an average of 78.2, demonstrating a strong grasp of fundamental numeracy concepts. Their small standard deviation of 4.7 suggests a relatively uniform understanding among most students. On the other hand, totally blind students scored an average of 60.5, indicating a lower comprehension level, with a higher standard deviation of 7.1, reflecting substantial variations between individuals. Some totally blind students understood basic concepts well, while others faced significant challenges. This discrepancy is mainly due to teaching methods that rely heavily on visual media to explain basic mathematical concepts, such as numerical symbols and simple arithmetic operations.

For Problem-Solving Skills, low-vision students achieved an average score of 71.8, demonstrating a moderate ability to solve numerical problems, with a standard deviation of 5.9, indicating a relatively consistent level of understanding. In contrast, totally blind students scored an average of 50.3, suggesting lower problem-solving skills, with a standard deviation of 6.4, indicating considerable variation. Some totally blind students managed to solve problems effectively, while others struggled with more complex problem-solving concepts. This difference suggests that low-vision students benefit from the ability to understand word problems or scenarios requiring numerical representation and symbols, which are typically presented visually.

Regarding Data Representation and Interpretation, low-vision students scored an average of 74.1, indicating strong comprehension of data representation, with a small standard deviation of 4.5, reflecting a relatively uniform understanding. Meanwhile, totally blind students scored 58.7, showing lower comprehension levels, with a standard deviation of 5.9, indicating that while some students could interpret data reasonably well, others struggled to understand different data forms. This issue arises due to the limited availability of tactile-based diagrams and graphs in daily learning for totally blind students.

B. Discussion

The findings suggest that the degree of visual impairment significantly affects students' numeracy literacy skills. Low-vision students consistently achieved higher scores across all assessed aspects compared to totally blind students. The primary factors influencing these results include access to visual information, teaching methods, availability of assistive tools, and the duration and intensity of numeracy practice.

To bridge this gap, greater efforts are needed to develop more inclusive teaching methods, such as technology integration and teacher capacity-building in teaching numeracy to visually impaired students. With proper intervention, this disparity can be reduced, ensuring that all students, including those with visual impairments, have better access to quality numeracy education.

This study aligns with Figueiredo et al. (2019), who stated that low-vision students retain residual vision, allowing them to recognize numbers, symbols, and patterns with the aid of magnifiers or digital screens. Conversely, Wijayanti et al. (2021) found that totally blind students rely solely on braille and tactile tools, requiring more time to process information.

In numeracy learning, much of the content is presented visually, such as in diagrams, tables, and graphs. Tarsidi (2021) reported that low-vision students can still access this material using magnifiers or software, whereas totally blind students, according to Sari (2022), must depend on touch-based methods, which are not yet as effective as visual methods.

C. Observations

1. Findings from Observations on Numeracy Literacy Learning for Blind Students

Observations in this study were conducted to understand how blind students, including those with low vision and total blindness, interact with numeracy materials in their learning environment. The results indicate significant differences in learning strategies, the use of assistive devices, and comprehension levels between these two groups.

2. Learning Patterns of Low Vision and Totally Blind Students

a. Low Vision Students

Students with low vision have an advantage in accessing numeracy materials compared to totally blind students. They can still perceive numbers, symbols, and diagrams, albeit with the assistance of magnifiers or high-contrast digital screens. Key characteristics observed in their numeracy learning sessions include:

- Use of visual aids: Most low vision students utilize magnifiers, screen readers, or digital devices that can enlarge text and numbers.
- Response to visually based materials: These students demonstrate quicker comprehension of numbers and symbols since they retain limited visual access.
- Difficulties with small or highly detailed materials: Diagrams or graphs with multiple elements pose challenges.
- Need for adjustable lighting and contrast settings: Students express a preference for learning environments with customizable lighting and high-contrast text.

b. Totally Blind Students

Students with total blindness face more complex challenges in numeracy learning. Observations highlight that:

- Reliance on tactile-based assistive tools: They heavily depend on braille, tactile tools, and voice-based technologies to comprehend numerical concepts.
- Longer learning duration: Compared to low vision students, they require extended time to grasp numerical concepts, especially those involving spatial representation, such as geometry or tables.
- Difficulties visualizing numerical concepts and mathematical operations: Lacking direct visual representation, they construct numerical understanding through tactile and auditory methods.

c. Use of Assistive Tools in Numeracy Learning

Observations also recorded various assistive tools used to support numeracy learning among blind students:

- Braille Mathematics: Many totally blind students rely on braille to read numbers and solve mathematical problems. However, braille has limitations in representing complex symbols such as fractions and equations.
- Talking Calculators: These devices assist students in performing quick calculations without requiring braille number reading.
- Tactile Diagrams: The use of tactile-based diagrams helps students understand geometric concepts and numerical relationships, although their availability remains limited. d. Voice-Based Software: Some students use applications that read math problems aloud and provide verbal feedback, enhancing their comprehension.

d. Challenges in Numeracy Learning

Observations revealed several key challenges faced by blind students in numeracy learning:

- Limited access to appropriate learning materials: Many school numeracy materials remain visually oriented, lacking alternatives in braille or audio formats.
- Difficulty in understanding diagrams and tables: Totally blind students struggle significantly with numerical representations in graphs and diagrams due to the lack of available tactile media.
- Lack of teacher training in teaching numeracy to blind students: Some teachers experience difficulties in applying effective numeracy teaching methods for blind students.

e. Effective Strategies to Improve Numeracy Literacy for Blind Students

Based on the observations, several strategies can be implemented to enhance numeracy literacy for blind students:

- Utilization of Multisensory Media: Integrating voice-based, tactile, and braille tools into numeracy instruction can help students grasp concepts more effectively.
- Teacher Training in Numeracy Instruction for Blind Students: Teachers require specialized training to adopt more inclusive, student-centered teaching methods.
- Expanded Provision of Assistive Tools: Schools should develop more assistive devices such as tactile diagrams, voice-based software, and braille-formatted materials to improve accessibility.
- Extended Learning Time and Personalized Guidance: Totally blind students need additional time to comprehend numeracy concepts, and flexible learning programs can support their understanding.

Observational findings indicate that blind students employ different learning strategies in numeracy literacy, depending on the severity of their visual impairment. According to research by Damayanti et al. (2024), low vision students grasp visually based concepts more quickly, whereas totally blind students, as found in Nurhadi, A. (2023), require touch- and sound-based learning methods. Providing more assistive tools and intensive teacher training can optimize and enhance inclusive numeracy learning for blind students.

D. Interviews

1. Findings from Interviews on Numeracy Literacy Learning for Blind Students

Interviews with students and teachers provided additional insights into the challenges and strategies implemented in numeracy literacy learning for blind students. Below are excerpts from the conducted interviews.

a. Interview Excerpts with Low Vision Students

Student A: "I prefer using screen readers and magnifiers to read numbers and problems. If there are many diagrams, I can see them but need to move closer to the screen."

Student A's response highlights that technological assistive tools, such as screen readers and magnifiers, significantly aid their mathematical comprehension. However, they face challenges in interpreting diagrams if they are too small or complex, demonstrating the need for adjusted display sizes and contrast.

Student B: "Sometimes I struggle when the teacher explains too quickly, especially during calculations. I need to take notes and reread them." Student B indicates that the teacher's delivery speed affects numeracy comprehension. They require extra time to review and understand concepts, emphasizing the necessity of flexible teaching strategies such as voice recordings or digital materials that allow for revisiting lessons.

b. Interview Excerpts with Totally Blind Students

Student C: "I use braille, but long problems can be difficult. If there are large numbers or tables, I have to read them multiple times." Student C highlights the challenge of reading lengthy problems, particularly those involving large numbers or tables. This suggests that numeracy materials should be more concise and accessible for totally blind students. Assistive tools such as talking calculators or tactile diagrams could facilitate better comprehension.

Student D: "I prefer when problems are read aloud or available in audio format. If I rely solely on braille, it takes longer for me to understand." Student D demonstrates a preference for audio-based learning over braille, showing that blind students have diverse learning styles. Therefore, integrating voice-based technology into numeracy instruction is essential to improving learning effectiveness.

c. Interview Excerpts with Teachers

Teacher X: "Totally blind students require special assistance. We often use tactile tools, but limited facilities pose challenges." Teacher X highlights the need for specialized support in numeracy learning for totally blind students. Despite using tactile tools, inadequate facilities remain a major obstacle. This finding underscores the importance of investing in more comprehensive assistive tools in inclusive schools.

Teacher Y: "Low vision students tend to grasp numeracy concepts faster than totally blind students. However, they still need specific strategies for complex problem-solving." Teacher Y confirms that low vision students have an advantage in numeracy learning but still require adapted teaching methods for complex problems. This indicates that despite better visual access, low vision students still face challenges that need to be addressed through adaptive teaching approaches.

2. Challenges Identified from Interviews

Interviews revealed key challenges in numeracy literacy learning for blind students:

a. Limited Access to Visual Materials
b. Lack of Alternative Material Formats
c. Limited Facilities and Assistive Tools
d. Strategies for Effective Numeracy Learning

- Developing audio-based learning media
- Enhancing access to assistive tools
- Providing teacher training on numeracy instruction for blind students
- Integrating technology to improve accessibility

Research by Anggraeni, N. N., & Indrakurniawan, M. (2023) suggests that low vision students benefit from visually adjusted materials, while Hasanah, R., et al. (2021) highlight that totally blind students require audio- and tactile-based learning approaches. Implementing more inclusive strategies will foster better numeracy comprehension and independence among blind students.

IV. CONCLUSION AND RECCOMENDATIONS

A. Conclusions

The findings of this study indicate that the degree of visual impairment has a significant impact on students' numeracy literacy abilities at the Indonesian Foundation for Blind Education (YAPTI). Students with low vision consistently outperformed totally blind students across all assessed aspects. The primary factors influencing these outcomes include access to visual information, instructional methods, availability of assistive tools, and the duration and intensity of numeracy practice.

Specifically, students with low vision demonstrated superior abilities in recognizing mathematical patterns and relationships, understanding fundamental concepts, and problem-solving. This advantage stems from their ability to perceive numbers, symbols, and patterns with the aid of visual assistive devices such as magnifiers and high-contrast digital screens. In contrast, totally blind students rely predominantly on braille-based and tactile learning methods, which require more time to process numerical information.

Observations and interviews further revealed various challenges faced by blind students, including limited access to visual learning materials, the lack of alternative formats such as audio-based content, and inadequate assistive facilities in schools. Additionally, insufficient teacher training in numeracy instruction for blind students remains a significant barrier to creating a more inclusive learning environment.

A. Reccomendations

To enhance numeracy literacy among blind students, the development of multisensory learning media that integrates auditory, tactile, and AI-based technologies is essential for optimizing concept comprehension. Schools should also increase the availability of talking calculators, voice-assisted software, and tactile learning tools to improve accessibility in numeracy education. Specialized training programs for teachers are crucial to equipping them with inclusive and technology-driven instructional methods.

Numeracy learning materials should be provided in multiple formats, including braille, audio, and interactive digital applications, to cater to students with different levels of visual impairment. Totally blind students require more flexible learning schedules and additional instructional support to develop a deeper understanding of numerical concepts. Moreover, integrating technology in the learning process—such as screen reader applications and audio-based e-learning platforms—should be expanded to enhance both the effectiveness and accessibility of numeracy education for blind students.

The implementation of these strategies is expected to bridge the numeracy literacy gap and foster a more inclusive and equitable learning environment for all students.

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