



Assistive Technology in Mathematics Learning for Visually Impaired Students

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Abstract: Mathematics is an important subject to be learned by all children. Visually impaired children experience obstacles in following the process of mathematics learning caused by abnormalities. Visually impaired students experience obstacles in the process of thinking at the disequilibrium stage and low understanding of concepts when studying mathematics. It caused them to experience difficulties when doing math problems. Assistive technology is a technology created specifically to improve or maintain the functional ability of children with special needs in order to accomplish tasks that hard for them to do. Assistive technology for visually impaired children is made by maximizing the abilities that the children still possess and helping them to get a clearer mathematical concept. This article is a literary study which aims to provide information about the difficulty for the visually impaired students in mathematics learning and assistive technologies that have been developed to support the learning. This article can be used as the basis for developing new assistive technology in mathematics learning. Assistive technology is needed to help children with visual impairment in following the learning of mathematics and to optimize the ability of the children in learning mathematics.

INTRODUCTION

Visually impaired children are children who experience obstacles in their eyesight (Mambela, 2018). These obstacles cause them to experience problems in daily activities (Wahyuni, 2017). One of the activity is learning. Learning is an attempt to increase oneself's knowledge to be more independent in the face of global development (Asfaroh, Rosana, & Supahar, 2017). Visually impaired children experience obstacles in learning visual materials. In addition, understanding of the elusive symbols except using visuals is also a barrier for

students with visual impairment in learning (de Oliveira, do Nascimento, & Bianconi, 2017).

The subjects that are difficult to learn by visually impaired children are mathematics (Diyansyah, 2017). In learning mathematics, visually impaired children have difficulty in understanding the mathematical symbols. It also affects the difficulty in performing arithmetic operations that exist in mathematics subjects. Mathematics is an important subject to be learned by children because it is useful for everyday life activities such as in the sale, purchase, measurement, and other activities. In the

era of science and technology, visually impaired children need to understand the basics of mathematics in order to play a role in society well (Sanchez & Flores, 2004). Therefore, visually impaired children need help to overcome these obstacles so that children can learn independently (McCarthy & Shevlin, 2017; Tiofan, Tolle, & Amalia, 2017). One solution to overcome this problem is by utilizing the development of the technology called the assistive technology.

Assistive technology is one of the efforts to help children with visual impairment in learning mathematics. The technology is designed with customized capabilities possessed by children so that children will be easier in following the learning, especially on learning mathematics. With the development of science and technology, a lot of assistive technology that has been developed to meet the learning needs of the visually impaired children. The development of assistive technology is growing rapidly; many studies have been done by experts (Wiazowski, 2009).

This article aims to provide information on visual impairments in learning mathematics and assistive technologies that have been developed to help visually impaired children in studying mathematics.

METHOD

The method used in this study is literary study. Literary study is a series of activities related to collecting literature data, reading and recording, and processing of library materials (Khatibah, 2011). These activities are not separated from the collection of library materials in the form of printed media, electronic media, as well as documents related to the library; literary study can collect the data from the said collection.

Sources of literature in this study were obtained from journals, books and

research results (thesis and dissertation). The general process of this study is conducted by identifying the theory systematically, library discovery, and document analysis containing information related to the topic researched.

RESULT AND DISCUSSION

A. The Concept of Visual Impairment

Sightless children are children with physical impediments. Understanding of the visually impaired by Stewart "*Visual Impairment is defined as sight loss that cannot be corrected using glasses or contact lenses. Several academic studies have concluded that, in general, visual impairment has a negative impact on educational attainment*" (Stewart, 2014; Tauda, Soedwihjono, & Putri, 2017).

Another opinion proposed by Sunanto that defines children with visual impairment in children who have limitations or obstacles or things that are not profitable in carrying out its function as a result of impaired vision (Sunanto, 2005). In addition, the visually impaired children are children with visual impairment or impaired vision, expressed by the level of visual acuity or centralized vision above 20/200 and pedagogically requires special education services in school (Suparno, 2007). It can be concluded that the visually impaired child is a child who has lost some or all of his vision which causes him to have barriers to his learning and thus requires special education.

Visually impaired children are characterized by the abnormality they have. United Nations Educational, Scientific and Cultural Organization classify visually impaired children into two namely *sightlessness* and *low vision*:

1) *Sightlessness: A person who is sightless has a total or high degree of vision loss. About 18% of sightless people are totally sightless - the remaining 82% can distinguish between light and dark.*

2) *Low Vision: visual vision (glasses or contact lenses) causes a visual impairment known as "low vision." A person with low vision has severely reduced visual acuity, significantly obstructed visual field, contrast sensitivity, or all three. The World Health Organization's definition of low vision is visual acuity less than 6/18 and equal to 3/60 in the best eye with the best correction.*

According to Lowenfeld in Sunanto; loss of vision resulted in three serious limitations, namely: Variation and type of experience (cognition), ability to move in the environment (orientation and mobility), and interact with the environment (social and emotional) (Sunanto, 2005).

Other opinions reveal that the characteristics of the visually impaired children are as follow:

1. Visually Impaired's Intellectual Development

Visually impaired children face low cognitive due to lack of information and left behind in the quantity of information channeled through the senses of vision. In this case, the ability to process information often ends in a fragmented sense and deviates from a simple concept.

2. Low self-esteem

Low self-esteem arises in the visually impaired person because of his disability. Unlimited visual experiences are limited, such as in moving, playing, or communicating with others resulting in the low self-esteem and lack of confidence.

3. Sightless Language Development

Sightlessness can interfere with the child's language skills but not overly interfere with the ability of children to communicate.

4. Easily Offended

Based on everyday experiences, visually impaired children often feel disappointed, frustrated, and unhappy

with the attitude of others who offend them.

5. Dependence on Others

Sightless children need help from others in various daily activities as a logical consequence of sightlessness, although not all activities need help.

B. Mathematics Learning

According to Hudoyo in Supardi, mathematics is a matter of ideas, structures, and relationships arranged in a logical sequence (Supardi, 2012). Thus, mathematics deals with abstract concepts developed for logical reasons, to prove a statement, true or false. Meanwhile, according to Sumarmo in Tapantoko, mathematical learning is directed to develop mathematical thinking ability, which includes comprehension, problem-solving, reasoning, communication, mathematical correction, critical and objective attitude (Tapantoko, 2011).

Mathematics education aims to study the factors that influence the learning of mathematics and to develop programs to improve the teaching of mathematics. It fits the opinion of Godino & Batanero "*Mathematics education is aimed to study the factors affecting the teaching and learning of mathematics and to develop programs to improve the teaching of mathematics*" (Godino & Batanero, 2007). The National Council of Teachers of Mathematics (NCTM) establishes five standards of mathematical ability that students must possess, namely problem-solving skills, communication skills, connection capabilities, reasoning and representation (National Council of Teachers of Mathematics (NCTM), 2000).

Application of mathematics learning is very useful in everyday human activities, such as in the activities of buying and selling transactions, measuring, calculating the distance, and so forth (Herwanto, 2013). According to Mensah Mathematics is necessary for our daily lives, regardless of our educational

background or social status (Mensah, 2017). The benefits of mathematics are not just limited to knowledge in computing, but more importantly, when every individual can master mathematics well, then their thinking patterns are more rational and critical.

Hadjichristou also explained that Mathematics is communicated through language, and thought is the communicated language (Hadjichristou, 2008). This analogy shows us that mathematics is a way of thinking. Mathematics helps people to create and solve problems by thinking objectively, independently and confidently in explaining relationships. Thus, these facts make mathematics education very important in all educational systems.

C. Visually Impaired Obstructions in Mathematics Learning

The loss of sight causes visually impaired children to experience obstacles in performing daily activities. One of them is in learning activities, visually impaired children experience barriers to understanding a concept because of the lack of visual experience. We know that the information we get is mostly obtained through vision. Therefore, visually impaired children experience limited visual information that affects a low understanding of concepts. This is in line with Hadi's point of view that visually impaired children have difficulty in assimilation and accommodation at the pre-concept stage caused by limited environmental experience, difficulty in direct connection with objects, touch perceptions, limited opportunities to expand language skills due to their basic experience (Hadi, 2005).

In their role as students at the school, visually impaired children tend to have difficulty in developing abilities, even in almost every field of study, and one of them is the field of mathematics. In general, visually impaired children have a

lower value in the field of mathematics studies than normal children (Astuti, 2015). This is because the visually impaired child has difficulty in understanding the elusive mathematical symbols. In addition, according to Akpan & Beard "*Math learning difficulties of students, such as verbalizing the problem, estimation, problem-solving, and organization*" (Akpan & Beard, 2014). Which means visually impaired children have difficulty in learning math in terms of verbalization problems, estimation, problem-solving, and organization.

Lesmana, Susanto, and Oktavianingtyas explain that in the process of thinking and solving math problems, visually impaired students have difficulty in the process of disequilibrium (Lesmana, Susanto, & Oktavianingtyas, 2015). This is proven by the results of their research that in solving math problems, visually impaired students need to read over and over before understanding the problem and can answer the problem. The activity is carried out many times using their sense of touch through reading the Braille letters, before entering the stage of assimilation, accommodation, and equilibrium.

The most difficult mathematics lessons learned by sightless children are materials that require more visual observation, such as a two-dimensional figure, three-dimensional figure, circumference and volume (Nurmitasari, 2015). These materials make the visually impaired children have more difficulty than other materials, although they also experience difficulties in learning other materials. Susanto explains that based on the level of Van Hiele thinking, it can be seen that the visually impaired students are at level 0 visualization with tactual visualization because the students learn the two-dimensional figure and three-dimensional figure by touching (Susanto, 2013).

This low visual experience causes visually impaired students to have difficulty in identifying two-dimensional figure, providing examples of objects, solving problems related to the shape and objects of the figures (Hidayati, 2016). Therefore, it takes assistive technology that enables the visually impaired children to learn difficult material and to optimize their learning achievement in math.

D. Assistive Technology

Assistive technology is one effort to help children with visual impairment in doing their daily activities. According to Wong & Cohen, assistive technology is any commercially acquired or manufactured goods or equipment used to enhance or maintain the functional capability of persons with disabilities (Wong & Cohen, 2011). Another opinion Assistive Technology (AT) is an item that allows disabled people to complete tasks that they should not be able to do because of their disability (Buehler et al., 2015). So it can be concluded that assistive technology is a technology that is made specifically to improve or maintain the functional ability of children with special needs in order to complete tasks that they should not be able to do. Assistive technology can be items, tools, or products made by teachers, designed to improve students' functional abilities. This is in accordance with the opinion of Akpan & Beard "*Assistive Technology can be any item, piece of equipment, or teacher made product that is designed to improve a student's functional capability*" (Akpan & Beard, 2014).

The National Assistive Technology Research Institute (NATRI) at the University of Kentucky examined the use of assistive technology in 10 US states in 2005 and found that assistive technology was more used by students with disabilities such as autism, hearing loss, or visual impairment than students with learning disabilities (Hasselbring &

Bausch, 2006). According to Sugiarmun, the specific target's activity on utilizing technology assistive are (Sugiarmun, n.d.):

- a. Motivating and fun
- b. Frequently conducted
- c. Providing the opportunity for independence in at least one of the following areas: verbal communication, written communication, numeracy, mobility, attention to oneself, vocational ability, or environmental control
- d. Activities that students cannot accomplish without the aid of such helpful technology.

E. Assistive Technology in Mathematics Learning for the Visually Impaired Students

Assistive technology is one of the factors that determine the high understanding of the visually impaired students in math lessons. The intrinsic factors that affect the level of understanding of visually impaired students' math are:

- a. The physical condition of students with visual impairment
- b. Students' intelligence
- c. Lack of stimulus and motivation
- d. Psychological factors of the students before the learning begins
- e. The cause and time of the visual impairment.

While extrinsic factors that influence the level of students' mathematical understanding include:

- a. Inadequate class conditions
- b. Lack of media or an assistive technology that teachers use in mathematics learning.
- c. The existence of the teacher
- d. The material being taught.

With the development of science and technology, the assistive technology for visually impaired children has also been developed and many pieces of research have been developed, such as:

1. Herwanto's study entitled *"Improving Mathematics Learning Achievement of Multiplication through Abacus Media for Visually Impaired Students"* resulted that Abacus can improve mathematics learning achievement for students with visual impairment (Herwanto, 2013). Abacus is a calculating tool consisting of beads that have certain values, ranging from units, tens, hundreds, thousands, and so on. Abacus is a quite practical tool to be used not only by students but also can be used by students with visual impairment through modification (Herwanto, 2013).
2. Research conducted by Primasyah with the title *"Development of Audio-Based Mathematical Learning Tools On Circumference and Area of Triangle for Visually Impaired Students at SMPLB TPA Jember"* using mathematical tools equipped with audio to facilitate visually impaired students in learning mathematics with the subject of circumference and area of a triangle (Primasyah, 2013)
3. Research conducted by Windasari under the title *"Interactive Media Learning Design of Full-Audio CD and Mathematical Learning Aids for Building Curved-face three-dimensional objects for Elementary High School Students Exceptionally Sightless (SMPLB-A)"*. The assistive technology developed for the visually impaired students is a fully interactive CD audio for the visually impaired in learning curved-face three-dimensional objects mathematics material (Windasari, 2011).
4. Nurajab modifies the domino game method by adding braille letters to improve the ability of addition and subtraction in mathematics learning (Nurajab, 2015). In his research, it is found that the modified game can help to improve the ability of the addition

and subtraction of visually impaired students in learning mathematics.

5. Karnadi developed a braille monopoly media in the material of mixed rational number for visually impaired learners (Karnadi, 2016).
6. Tufani made modifications to the geoboard equipped with audio to help children with visual impairment in learning two-dimensional figures material (Tufani, 2017). The tool, once tested, proved to be effective in assisting the visually impaired students in understanding the circumference of two-dimensional figures material.

Optical Character Recognition (OCR) and Descriptive Video Services (DVS) are technologies that can be used to help visually impaired students in learning mathematics by scanning material through Optical Character Recognition (OCR) that can scan and read printed texts, enabling them with visual impairments to access all types of printed materials and enabling them to read the material independently. The scanned material can be read using Descriptive Video Services (DVS) commonly called screen reader which allows the computer to read all the data on the computer orally (Hasselbring & Glaser, 2000).

View Plus Accessible Graphing Calculator is an assistive technology that enables the visually impaired to be able to read graphics through audio. In addition, there are also MathTalk applications that can help visually impaired students in translating mathematical problems into Braille. Select Math Program with Boston Public Schools is a website that provides access to learn math and it has been adapted for the children with visual impairment (Akpan & Beard, 2014).

From various researches on assistive technology in mathematics learning, almost all of them develop various technologies that can optimize the sensory capabilities that are still owned by the visually impaired such as touch, smell,

and others in studying mathematics subjects. This is because the visually impaired children's condition is abnormal in their visual, so assistive technology is directed to optimize their other still functioning senses.

The technology seeks to help students to be easier to understand the material at the disequilibrium stage. If the students are able to pass the stage well, then it will be easier for them to do the thinking process in solving mathematical problems in the next stage (Lesmana et al., 2015). Assistive technology is also directed to facilitate students with visual impairment in learning certain materials that are difficult to learn, broaden their understanding of the concepts and reduce some difficulties encountered when doing mathematical problems.

CONCLUSION

Visually impaired students experience obstacles in the process of thinking disequilibrium and low understanding of concepts when they are studying mathematics. This causes the students to experience difficulties when doing mathematical problems. Assistive technology for the visually impaired children has grown rapidly in helping them to follow math learning. Assistive technology for visually impaired children is made by maximizing abilities that children still have and helping children to get a clearer mathematical concept.

It is expected for the future researcher to create assertive technology that can help children with visual impairment, especially in learning mathematics. So that they can learn mathematics well and have optimal learning achievement. Research on the development of assistive technology for the visually impaired children in learning mathematics is necessary because children with visual impairment need it to facilitate them in learning mathematics.

REFERENCES

- Akpan, J. ., & Beard, L. . (2014). Assistive Technology and Mathematics Education. *Journal of Educational Research*, 2(3), 219–222.
- Asfaroh, J. ., Rosana, D., & Supahar. (2017). Development of CIPP Model of Evaluation Instrument on the Implementation of Project Assessment in Science Learning. *International Journal of Environmental and Science Education*, 12(9), 1999–2010.
- Astuti, V. . (2015). Identifikasi Proses Berpikir Berdasarkan Asimilasi dan Akomodasi dalam Memecahkan Masalah Geometri pada Siswa SMP Penyandang Tunanetra. In *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika* (pp. 255–265). Surakarta: Universitas Muhammadiyah Surakarta.
- Buehler, E., Branham, S., Ali, A., Chang, J. ., Hofmann, M. ., & Kane, S. . (2015). *Sharing is Caring: Assistive Technology Designs on Thingiverse*. https://www.colorado.edu/cs/sites/default/files/attached-files/sharing_is_caring_assistive_technology_designs_on_thingiverse.pdf.
- de Oliveira, F. S., do Nascimento, A. S., & Bianconi, M. L. (2017). Teaching Enzyme Activity to the Visual Impaired and Blind Students. *Technologies*, 5(52), 1–11. <https://doi.org/10.3390/technologies5030052>
- Diyansyah, G. . (2017). *Pengaruh Media Numicon Terhadap Peningkatan Prestasi Belajar Matematika Anak Tunanetra kelas III di SLB A YKAB Surakarta Tahun Ajaran 2016/2017*. Universitas Sebelas Maret.
- Godino, J. ., & Batanero, C. (2007). The Onto-Semiotic Approach to Research in Mathematics Education. *ZDM Mathematics Education*, 39,

- 127–135.
- Hadi, P. (2005). *Kemandirian Tunanetra*. Jakarta: Direktorat Jendral Pendidikan Tinggi.
- Hadjichristou, C. (2008). A Comparative Study on Math's Education Rendered in the Two Communities on the Island of Cyprus. *International Journal Of Environmental & Science Education*, 2(2), 38–43.
- Hasselbring, T. ., & Bausch, M. . (2006). Assistive Technologies for Reading. *Educational Leadership*, 63(4), 72–75.
- Hasselbring, T. ., & Glaser, C. H. . (2000). Use of Computer Technology to Help Students with Special Needs. *Children and Computer Technology*, 10(2), 102–122.
- Herwanto, S. (2013). *Peningkatan Prestasi Belajar Matematika Materi Perkalian Melalui Media Abakus Bagi Siswa Tunanetra*. Retrieved from <https://eprints.uns.ac.id/1884/1/1803-4030-1-PB.pdf>
- Hidayati, A. (2016). *Analisis Kesulitan Belajar Siswa Tunanetra kelas VIII dalam Menyelesaikan Soal Sudut dan Segitiga di SMP Negeri Bondowoso*. Universitas Jember.
- Karnadi. (2016). *Pengembangan Media Monopoli Braille pada Pelajaran Matematika dalam Materi Operasi Hitung Campuran bagi Peserta Didik Tunanetra Kelas V SDLB Negeri Lamongan*. Universitas Negeri Malang.
- Khatibah. (2011). Penelitian kepustakaan. *Jurnal Iqra'*, 5(1), 36–39.
- Lesmana, I., Susanto, & Oktavianingtyas, E. (2015). Proses Berpikir Siswa Tunanetra dalam Memecahkan Masalah Kubus dan Balok Kelas IX di SMPLB-A Taman Pendidikan dan Asuhan Jember. *Kadikma*, 6(3), 88–98.
- Mambela, S. (2018). Tinjauan Umum Masalah Psikologis dan Masalah Sosial Individu Penyandang Tunanetra. *Jurnal Buana Pendidikan*, 14(25), 65–73.
- McCarthy, P., & Shevlin, M. (2017). Opportunities and challenges in secondary education for blind/vision-impaired people in the Republic of Ireland. *Disability and Society*, 32(7), 1007–1026. <https://doi.org/10.1080/09687599.2017.1337564>
- Mensah, F. . (2017). Ghanaian Senior High School Students' Error in Learning of Trigonometry. *International Journal Of Environmental & Science Education*, 12(8), 1709–1717.
- National Council of Teachers of Mathematic (NCTM). (2000). *Principle and Standards for School Mathematics*. NTCM.
- Nurajab, D. . (2015). *Keefektifan Metode Permainan Domino Braille terhadap Kemampuan Penjumlahan dan Pengurangan pada Mata Pelajaran Matematika Siswa Tunanetra kelas I di SLB A Yaketunis Yogyakarta*. Universitas Negeri Yogyakarta.
- Nurmitasari. (2015). Pola Penerimaan Siswa Tunanetra dalam Pembelajaran Matematika di SMPLB. *Jurnal E-DuMath*, 1(2), 82–88.
- Primasyah, T. (2013). *Pengembangan Alat Peraga Matematika Berbasis Audio Pada Pokok Bahasan Keliling dan Luas Segitiga Untuk Siswa Tunanetra SMPLB TPA Jember*. Universitas Jember.
- Sanchez, & Flores. (2004). AudioMath: Blind Children Learning Mathematics Through Audio. In *5th Intl Conf. Disability, Virtual Reality & Assoc. Tech., Oxford, UK* (p. 184).
- Stewart, J. (2014). Visual Impairment and Educational Attainment. *Research and Information Service*, 2.

- Sugiarmim, M. (n.d.). *Pengembangan Teknologi Asistif Bagi Anak Berkebutuhan Khusus Dalam Setting Pendidikan inklusif*. Universitas Pendidikan Indonesia.
- Sunanto, J. (2005). *Potensi Anak Berkelainan Penglihatan*. Jakarta: Dirjen Dikti.
- Supardi, U. . (2012). Peran Berpikir Kreatif dalam Proses Pembelajaran Matematika. *Jurnal Formatif*, 2(3), 248–262.
- Suparno. (2007). Pendidikan Anak Berkebutuhan Khusus. In *Konsorsium Program SI PGSD*. Direktorat Jendral Pendidikan Tinggi.
- Susanto. (2013). Analisis Proses Pembelajaran Siswa Tunanetra Dalam Memahami Segiempat di SLB Taman Pendidikan dan Asuhan Jember Kaitannya Dengan Tingkat Berpikir Geometri Van Hiele. In *Seminar Nasional MIPA & Pembelajaran MIPA*. Universitas Jember.
- Tapantoko, A. . (2011). *Penggunaan Metode Mind Map (Peta Pikiran) untuk meningkatkan motivasi Belajar siswa dalam Pembelajaran Matematika Siswa Kelas VII SMP Negeri 4 Depok*. Universitas Yogyakarta.
- Tauda, Y. A., Soedwiwhjono, & Putri, R. A. (2017). Kesesuaian Pemenuhan Kebutuhan Difabel Tunanetra dan Tunaaksara di Kota Surakarta terhadap Kriteria Kota Ramah Difabel. *Region*, 12(2), 181–193. <https://doi.org/10.1016/j.molcatb.2009.06.001>
- Tiofan, L. T., Tolle, H., & Amalia, F. (2017). Rancang Bangun Aplikasi Messaging Berbasis Voice Interaction Bagi Penderita Tunanetra Pada Sistem Operasi Android. *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer*, 1(7), 620–627.
- Tufani, Y. . (2017). *Pengaruh Penggunaan Media Audio Geoboard untuk Meningkatkan Pemahaman Bangun Datar Materi Keliling pada Anak Tunanetra Kelas III SLB A YKAB Surakarta Tahun Ajaran 2016/2017*. Universitas Sebelas Maret.
- Wahyuni, R. (2017). Buku Gizi Braille sebagai Media Pendidikan untuk Meningkatkan Pengetahuan Anak Tunanetra. *Jurnal Unnes*, 1(1), 59–64. Retrieved from <http://journal.unnes.ac.id/sju/index.php/higeia>
- Wiazowski, J. (2009). *Assessing Students' Needs for Assistive Technology*.
- Windasari, R. (2011). *Desain Media Pembelajaran CD Interaktif Full-Audio dan Alat Peraga Matematika Pokok Bahasan Bangun Ruang Sisi Lengkung untuk Siswa Sekolah Menengah Pertama Luar Biasa Tunanetra (SMPLB-A)*. Universitas Jember.
- Wong, M. ., & Cohen, L. (2011). School, family and other influences on assistive technology use: Access and challenges for students with visual impairment in Singapore. *British Journal of Visual Impairment*, 29(2), 130–144.