Braille Inovation Technology in Teaching and Learning Process For Visual Impairment

Nur Fadhilah Tisnawati[1](*), Yuliati[2], Endang Purbaningrum[3]
[1,2,3]Universitas Negeri Surabaya, Surabaya, Indonesia

Abstract

The innovation of braille makes learning for children with visual impairments easier. The breakthrough braille innovation developed is able to encourage the creation of creative, active, and practical learning for children with visual impairments. This study aims to collect and analyze articles related to innovation technology of braille for teaching and learning process to visual impairment. The design of study used literature review that use data collection methods with search related topics, data analysis and also writing research results. The results of this study that braille innovations technology for reading, writing and conceptualizing of reading are useful in the learning process of children with visual impairments.

How to Cite: Tisnawati, N. F., Yuliati, & Endang Purbaningrum. (2022). Braille Innovation Technology in Teaching and Learning Process For Visual Impairment. JTP - Jurnal Teknologi Pendidikan, 24(2), 224-235. https://doi.org/10.21009/jtp.v24i2.24971

INTRODUCTION

Education will continue to develop with the existence of technology that accompanies every era that continues to race with innovation in all aspects of life. Likewise, the learning process will never stop at one method, but will also develop using other methods, using tools and media that are increasingly developing and experiencing updates. Thus, changes will continue to make the learning and teaching process experience an increase in the quality of teaching. The conveniences that are continuously sought and given innovations from the current conditions make the process experienced by students, especially for children with special needs, easier and more accessible according to the child's needs.

The innovations provided in the learning and teaching process of children with special needs must be in accordance with the needs and conditions of children who experience certain obstacles. This adjustment needs to be made so that mastery of the material being taught is able to develop the potential that children have and improve the quality of life for children with special needs, one of which is the use of braille in children with visual impairments. Mastery of braille letters is the basis for incoming knowledge as input from the reading process experienced by children with visual impairments, this process of mastering braille greatly affects the quality of literacy that is owned, not only the quantity that children can read, but also concepts ranging from mastery of letters to awareness of differences. arrangement of words in words and sentences (Barlow–Brown & Connelly, 2002; Matuszewski et al., 2021; Pring, 1982), for

Arabic, it greatly affects word mastery or phonological as well as the use of numbers and braille codes (Rączy et al., 2020).

Mastery of braille greatly affects the language skills possessed by children with visual impairments. Language skills which include reading, writing, listening and speaking cannot be separated from each other in order to achieve good language skills (D. Tarigan & Tarigan, 1987; H. G. Tarigan, 1987). Reading and writing are skills that are related to each other, the ability to read will affect the writing skills of students, it is through these reading skills that access to information is owned and then processed and issued in the form of new information through writing skills (H. G. Tarigan, 1981). The process of reading and writing children with visual impairments will be hampered if their mastery of braille has problems, this is where mastery of braille is important for children with visual impairments and the development of braille teaching technology also needs to be innovated according to children's needs. Reading ability, reading speed, and understanding of reading and the information it gets depend on the tactile abilities the child has, the more fluent the use of Braille, the better his language skills, especially reading skills (Chen et al., 2019).

The concept of literacy which is carried out by focusing on the process of reading braille is very dependent on fluency in reading braille which is also a problem if the language used is a second language. However, with the developments that have occurred, literacy education for children with visual impairments is easier in the learning process, for this reason, the development of braille media and technology is still very capable of the learning and teaching process using braille so that there are more updates with braille media that are suitable for the segments given teaching process using braille (Clunies-Ross, 2005). Many technological researches have been carried out to provide innovations in learning for children with visual impairments. mastery of the latest tactile technology, language concepts in learning and various kinds of textbooks made make technological innovations related to braille very adequate even though the need for innovation every year is still very much needed.

So that the research that has been carried out by many parties provides the best contribution to the implementation of the learning process, especially for the learning process of children with visual impairments in Indonesia, it is necessary to have a special discussion on learning technology and braille innovation. The latest research in Indonesia is Braille research aimed at learning innovation, no one has fully reviewed the research that has been done (Agustina & Farida, 2021; Aprilianti et al., 2012; Arif et al., 2021; Handoyo, 2019; Hidayat et al., 2016; Putra & Risdoyok, 2021; Ruwah et al., 2021). In fact, there is no full review of braille in learning so this article needs to be written and studied better in collecting braille innovations that have been found or developed for children with visual impairments.

This article will review and examine the studies that have been carried out by researchers in various journals. It also includes innovations in braille technology that have been carried out in Indonesia and in several other countries. The purpose of this article is to provide a comprehensive view in the form of a literature study that will discuss the latest research on braille innovations that were

created or developed in relation to supporting reading, writing and contextual thinking skills for children with visual impairments.

METHODS

This research on literature review was made by prioritizing several issues related to innovation in braille with several aspects of the discussion included in mastering braille which involves writing, reading to concepts that are able to provide technology and research novelties that have been developed to facilitate the use of braille, of course this is this relates to support for learning for children with visual impairments. So this research will specifically focus on studying topics related to it, focusing on innovations that already exist in Indonesia and are supported by technical braille innovations that have been developed in other countries. This literature review procedure will contain several steps in the process, including conducting managerial data in the form of articles and other forms of reference that have been carried out, analysing data relevant to this research topic, starting to synthesize data by rewriting it using a literature study draft and the last is the selection of the authorship of the article (Galvan & Galvan, 2019).

Data collection. The method used to select data sources from previous research articles was done by document analysis. The method used is to search, read, and review documents related to the topic of the article taken. After carrying out the process of reading and selecting these documents, further collection will be carried out based on the parts of the topic made or grouping based on the relationship between the subject matter of the articles studied, from this process the relevance of each existing research will be seen. This process is very important for researchers, because the analysis and grouping process they go through will provide a complete and complete perspective on Braille innovations that have been developed from year to year, from countries with different learning contexts.

Data analysis. The data collected is in the form of documents that have been grouped with the closest specification of the topic of discussion, then stored and printed which then becomes an important document in the assessment. The researcher analyses the documents one by one by reading the entirety of the parts in the document, to make it easier to collect data, the researcher uses an outline while still focusing on the big topics of this topic, namely seeing the goals of developing innovative products or methods generated from each research conducted and characteristics of braille innovations that were discovered and developed and their results.

RESULT & DISCUSSION

RESULT
Braille Writing Technology Innovations

Braille technology innovation that supports the braille writing process is needed so that there is reciprocity from the learning gained by children with visual

impairments, this reciprocity is of course in the form of writing written in braille. This braille writing form will be adapted to the braille format with six braille points that must be understood. In general, to do braille writing begins with writing using a technical manual with a stylus and reglet by directly using paper media and can be done by children using these tools with adjusted braille dots. The development of braille writing using manuals has been developed earlier and for a long time.

Braille manual writing does experience many difficulties in carrying out writing activities; even the stylus used for the braille writing process cannot be done anywhere. In addition, to provide complementary information or learning information that makes geometric images or shapes is also difficult to do when using a braille manual, for this reason, braille writing technology continues to be developed at this time. Apart from the technical elements of writing, difficulties in using the stylus and reglet when writing braille usually occur due to misconceptions and difficulty recognizing braille, so parents and teachers need assistance (Putnam & Tiger, 2015; Rudiyati, 2005). The development of braille writing technology has also emerged, from those using computers with separate writing boards, to portable braille devices that can be carried anywhere and connected by computers or tablets and smartphones that children have.

Development of a braille writing innovation tool by using 9 input board buttons that are connected to a braille reader application that is connected to a computer system, electronic braille reglet is a technological development that becomes a means of replacing reglets for braille writing with good development product results to use, even including it developed a voice reader that is able to record input written in braille written by students, this is what researchers call a screen reader (S. K. Hidayat et al., 2016). The easy input process from using this screen reader allows children to record their writing in the form of braille or audio output that can be used to support their learning.

Not only in Indonesian which incidentally was developed in Indonesia, development was also carried out with the same text reader concept but different text reader applications, development with different use of 6 braille keys and equipped with English to Indonesian translation and vice versa (H. Hidayat & Yusuf, 2020), braille code compiled with a simple keyboard writing in mandarin (Tang, 2013). The development of braille writing in languages other than Indonesian provides a significant difference because the braille used also differs from one country's language to another. However, this development in braille writing has a very significant effect for children in collaborating in language translation with the features on the tool that facilitates translating into other languages. The development continues by making access to software applications that make it easy to create text directly on a laptop or computer which was developed with voice translators in various languages (Abualkishik et al., 2015; Al-Salman, 2008; Scheithauer & Tiger, 2012).

Braille Reader Technology Innovations

The beginning of the introduction of reading that supports the learning of children with visual impairments using a grid that contains braille dots to make it

easier for children to understand braille letters, so that the media does not use wood anymore but uses paper media as a result of writing using a braille typewriter or manually using a reglet (Rudiyati, 2005). Product development of teaching materials that help mastery of reading become practical to use with basic needs in the teaching and learning process while facilitating mastery of braille codes so that they are easy to use as a reference for teachers and students to master the subject matter. The most important part of fluent use of braille and children's reading process is not influenced by time, seriousness, and cognitive experience, the most important thing is the availability of access to reading books that support the reading process, especially for children with simple language according to their literacy level (Laroche et al., 2017).

Among them is the development of teaching materials in the form of book products containing braille code with elaboration theory that puts forward the braille code layout with similar groupings to make it easier for teachers to teach and become teaching materials that are practically used during math, science and other lessons (Handoyo, 2019). The ability of children who use braille with the availability of braille teaching materials is more improved and their understanding is better than those who only print Latin letters (Veispak et al., 2012). This is because the availability of braille teaching materials fully guides children to understand written theory and not just listen to the teacher's presentation in the form of hearing. Mastery of material, exercises, and basic concepts will be easily accessible to students when the learning and teaching process is ongoing, the process of listening to readings in braille activates brain development in language which is transferred in the form of information on each subject given.

Access to reading books as the simplest means in the form of reading books, braille teaching materials in schools is still an important means of conveying information that improves braille reading skills, enthusiasm for learning, as well as developing hobbies and fostering the independence of children with visual impairments (Nahlisa & Christiani, 2015). When the smallest aspect of the Braille book media is not fulfilled, access to information will not be open, students will not be able to get to know other sciences.

As mastery of the Javanese language, which on average, teachers skip the introduction and writing of Javanese script due to limited access to books, media and teaching materials that lead to these materials, the development of the Javanese script learning module is the spearhead of the media to access the knowledge of children with visual impairments. Javanese script, the development of the "dinta swara" module which is a practical module for learning Javanese script is very much needed and used as a teaching and learning medium and has been tested for feasibility (Triyanto & Rudiyati, 2017). The development of media for writing Javanese script continues, research developed for the final project in the form of a thesis is called the "denta Jawa" application which innovates the integration of Javanese script with Braille in its original form (Sanandita, 2020).

Development continues, not only regarding braille teaching materials but also connecting with audiobooks equipped with tactile or braille tools to learn mathematics and teach these subjects (Purnamayanti & Putri, 2020; Subagya, 2017). This form of development in the audio version accelerates the braille reader which is connected to the most important part of the child's hearing sensor,

from this development will make learning more varied and access can be independent without the help of others who no longer require the child to be assisted.

Braille Innovation and Conceptualization of Reading

The importance of conceptual management of reading from a method that focuses on mastering the process of reading texts, with tactile in the form of braille media with the term foundational skills which include word identification, word analysis and reading fluency, which greatly influences the mastery of reading concepts. In fact, the process that occurs when reading is closely related to fluency in translating the concept of braille and is passed on to word or verbal pronunciation that is produced when the child begins to read aloud or conveys back the context of reading and writing that he has experienced as a learning experience using braille. So the conceptualization of this reading is closely related to the interpretation of Braille reading and the mastery of reading information they get (Dzięgiel-Fivet et al., 2021; Pring, 1982), this also applies to braille in other languages, not only English braille, such as mastery of Arabic braille reading conceptions (Rączy et al., 2020).

Several assessment instruments used to see fluency and accuracy in reading comprehension have been developed, to complete clarity in the contextualization of reading, the use of tests in the form of braille blocks arranged with novels for assessing fluency and reading comprehension was also presented as a test of the tactile abilities of children with disabilities. vision with precision reading mastery (Jarjoura & Karni, 2016), the implications of reading skills that are orbited for students to analyse and interpret reading so as to encourage them to understand the concept of reading that they are reading, including children with visual impairments (Johnstone & Thurlow, 2012). Thus, the understanding that will be processed by looking at the accuracy in reading Braille is very important and this has been proven by the development of an innovative conceptual assessment instrument in learning that students have. So, support for media that encourages the presence of new understanding that stimulates children to do deep understanding in the form of understanding metacognition that increases the learning process to be more real for children with visual impairments.

The context of the reading given using two dimensions to provide an understanding of the shape of the object that will be arranged with an electric board with unification or creations formed from braille dots, affects the conceptual quality of children towards objects, especially graphic forms into two dimensions (Bansevicius & Virbalis, 2007). The strengthening of reading concepts is supported by the tactile abilities of children, so that the development of novels with a 3-dimensional polymer system is carried out with a strategy of conceptualizing reading on film (Eleftheriadis & Fatouros, 2021). The conceptualization of reading was also developed in the form of a new braille display using a polymer which will later be read when the vibrations that occur in the device are processed, the tactile appearance that appears gives understanding to the reader conceptually through direct movement or touch on the device (Choon Koo et al., 2008).

DISCUSSION

Technological developments and innovations do not only extend to the tools developed to make it easier to write Braille manually and which have accelerated the computer reader system, the ease of use of software with a Robobraille assistant (Śmiechowska-Petrovskij & Kilian, 2016), the development of a tactile screen with a software polymer system to facilitate high-sensitivity typing (Choon Koo et al., 2008; Frediani et al., 2018). The design is in the form of a game that invites children's activities to write Arabic Braille by involving contextual learning so that children fully understand the Braille writing in Arabic letters (Jati & Mahardika, n.d.), so that the learning provided does not necessarily make it difficult for children to use braille writing tools, even the development of this technology is increasingly being developed with the direction of accessibility of tools that are easy and affordable by the community so that the mentoring process carried out by teachers in learning any subject becomes easier.

The era of digitization that makes everyone easily connected and has a gadget that can easily connect information, this condition encourages the development of portable devices without the need to carry a braille manual or braille input device into the computer. Braille writing also continues to be developed with a touch screen model, so that children with visual impairments can write easily without having to be constrained by physical tools that cannot be carried anywhere, such as using a touch braille application instead of a physical keyboard using a tablet screen (Alnfiai & Sampalli, 2016, 2017). The innovation of braille writing technology that was developed made a major contribution to the learning and teaching process, the conception of language that is not only verbal for children with visual impairments but also has language input and output in the form of writings that can be arranged in braille very easily.

Openness to technological innovations of conceptualization of reading is very closely related to processing the form of supporting images, formulas, designs and real concepts that exist in everyday life which involves understanding information about objects and the surrounding environment, including things that are difficult to reach if only given information. Information is only limited to braille in the form of a description. So the innovation technology for conceptualization of reading continues to be developed until it enters the development carried out by involving braille symbols between countries with their respective characteristics and different uses. Development with a new platform developed by incorporating the concept of a braille reader that focuses on ontology with an understanding that is put forward in learning (Tang, 2013).

Finally, this literature study is able to provide a specific view of the technologies that have been discovered and innovated in braille used for children with visual impairments. The collection of references relevant to this literature review gets a special view on the progress of the research that has been carried out, thus providing reinforcement to the topic of research regarding the development of braille for children with visual impairments, especially since this study has been taken from various multidisciplinary sciences that include braille innovation. however, to develop a study on the topic of braille, it is necessary to

focus on the practicality of the technology made, so that there is an acceleration of technology in education in the future.

CONCLUSION

The development of technology to support learning for children with visual impairments in Braille innovation makes education more innovative and the activities carried out by students become easier. Innovationthe technology developed includes technology that makes it easier for: (1) students to input text in the form of braille letters which are transferred in the form of digital data that is accessed on a computer using a braille manual that uses the development of typing tools or voice input that can be translated in braille form. Innovations in braille are also carried out in braille reader technology, which was developed with a focus on developing braille text that is easily understood by children with visual impairments, in this case the development of braille readers in books. Used for teaching materials and also reading books in several languages, so that the space for literacy children with visual impairments do not experience difficulties and access is difficult, (2) The development of conceptual supporting media for braille readers was also developed for children with visual impairments, innovations were developed in the form of instruments and reading mastery with reading strategies that students would do when they carried out the literacy process during class and outside the classroom. The design and design of images that support the conceptualization of reading in the form of 2 dimensions and 3 dimensions fully support the understanding of children with visual impairments in their learning process, (3) The technological innovation given to this braille reader was also developed in the form of screening on braille dots into android-based text with technology automatic braille reader logo.

This development was carried out to help children with visual impairments detect braille and respond to text by connecting it to an android, even this automatic braille point detector is able to read braille text in image form (Sulviyani et al., 2017), supported by a braille mouse which is the central connection for social media for use on smartphones or tablets which can greatly influence the development of social interaction, and the use of the latest technology that is connected to social media platforms in the form of chat quickly and can be used anywhere because it was developed without cable (Holanda et al., 2018).

CONFLICT OF INTEREST

Concerning the research, authorship, and publication of this paper, the author(s) reported no potential conflicts of interest.

REFERENCES

Abualkishik, A. M., Omar, K., & Odiebat, G. A. (2015). QEFSM model and

Markov Algorithm for translating Quran reciting rules into Braille code. Journal of King Saud University - Computer and Information Sciences, 27(3), 238–247. https://doi.org/10.1016/j.jksuci.2015.01.001

Agustina, R., & Farida, N. (2021). Braille Geometry Teaching Materials for Low Vision Students. Kreano, Jurnal Matematika Kreatif-Inovatif, 12(1), 63–74. https://doi.org/10.15294/kreano.v12i1.26562

Al-Salman, A. S. (2008). A Bi-directional Bi-Lingual Translation Braille-Text System. Journal of King Saud University - Computer and Information Sciences, 20, 13–29. https://doi.org/10.1016/s1319-1578(08)80002-x

Alnfiai, M., & Sampalli, S. (2016). SingleTapBraille: Developing a Text Entry Method Based on Braille Patterns Using a Single Tap. Procedia Computer Science, 94, 248–255. https://doi.org/10.1016/j.procs.2016.08.038

Alnfiai, M., & Sampalli, S. (2017). BrailleEnter: A Touch Screen Braille Text Entry Method for the Blind. Procedia Computer Science, 109(2016), 257–264. https://doi.org/10.1016/j.procs.2017.05.349

Aprilianti, D., Hendriawan, A., & Oktavianto, H. (2012). Alat Pembelajaran Huruf Hijaiyah Braille untuk Tuna Netra. The 14th Industrial Electronics Seminar 2012 (IES 2012) Electronic Engineering Polytechnic Institute of Surabaya (EEPIS), Indonesia, October 24, 2012(Ies), 40–45.

Arif, M., Kalimatusyaroh, M., & Setyawati, N. R. (2021). Optimalisasi Guru Dalam Menumbuhkan Minat Membaca Huruf Braille Pada Siswa Tunanetra. VOX EDUKASI: Jurnal Ilmiah Ilmu Pendidikan, 12(1), 38–57. https://doi.org/10.31932/ve.v12i1.1019

Bansevicius, R., & Virbalis, J. A. (2007). Two-dimensional Braille readers based on electrorheological fluid valves controlled by electric field. Mechatronics, 17(10), 570–577. https://doi.org/10.1016/j.mechatronics.2007.07.004

Barlow–Brown, F., & Connelly, V. (2002). The role of letter knowledge and phonological awareness in young Braille readers. Journal of Research in Reading, 25(3), 259–270. https://doi.org/10.1111/1467-9817.00174

Chen, X., Liang, L., Lu, M., Potměšil, M., & Zhong, J. (2019). The effects of reading mode and braille reading patterns on braille reading speed and comprehension: A study of students with visual impairments in China. Research in Developmental Disabilities, 91(November 2018). https://doi.org/10.1016/j.ridd.2019.05.003

Choon Koo, J., Ryeol Choi, H., Jung, K., Nam, J. do, Lee, Y. kwan, & Lee, S. (2008). A new Braille display system design using a polymer-based soft actuator tactile display. Dielectric Elastomers as Electromechanical Transducers, 239–248. https://doi.org/10.1016/B978-0-08-047488-5.00023-X

Clunies-Ross, L. (2005). Windows of perception: A review of the literature concerning uncontracted and contracted literary braille. The British Journal of Visual Impairment, 23(2), 67–74. https://doi.org/10.1177/0264619605054778

Dzięgiel-Fivet, G., Plewko, J., Szczerbiński, M., Marchewka, A., Szwed, M., & Jednoróg, K. (2021). Neural network for Braille reading and the speech-reading convergence in the blind: Similarities and differences to visual reading. NeuroImage, 231(February).

https://doi.org/10.1016/j.neuroimage.2021.117851

Eleftheriadis, G. K., & Fatouros, D. G. (2021). Haptic Evaluation of 3D-printed Braille-encoded Intraoral Films. European Journal of Pharmaceutical Sciences, 157, 105605. https://doi.org/10.1016/j.ejps.2020.105605

Frediani, G., Busfield, J., & Carpi, F. (2018). Enabling portable multiple-line refreshable Braille displays with electroactive elastomers. Medical Engineering and Physics, 60, 86–93. https://doi.org/10.1016/j.medengphy.2018.07.012

Galvan, J. L., & Galvan, M. C. (2019). Writing Literature Reviews: A guide for students of the social and behavioral sciences. In Statistical Field Theor (Vol. 53, Issue 9).

Handoyo, R. R. (2019). Pengembangan bahan ajar kode braille berbasis teori elaborasi bagi guru pendidikan khusus. JPK (Jurnal Pendidikan Khusus), 14(2), 46–56. https://doi.org/10.21831/jpk.v14i2.25166

Hidayat, H., & Yusuf, M. (2020). Rancang Bangun Perangkat Belajar Braille Elektronik Berbasis Raspberry Pi. Ultima Computing : Jurnal Sistem Komputer, 12(1), 1–8. https://doi.org/10.31937/sk.v12i1.1541

Hidayat, S. K., Suyanto, M., & Henderi. (2016). MODEL PEMBELAJARAN MENULIS BRAILLE. 2(1), 44–55. http://journal.amikomsolo.ac.id/index.php/itcida/article/view/23

Holanda, G. B., Souza, J. W. M., Lima, D. A., Marinho, L. B., Girão, A. M., Bezerra Frota, J. B., & Rebouças Filho, P. P. (2018). Development of OCR system on android platforms to aid reading with a refreshable braille display in real time. Measurement: Journal of the International Measurement Confederation, 120, 150–168. https://doi.org/10.1016/j.measurement.2018.02.021

Jarjoura, W., & Karni, A. (2016). A novel tactile braille-stroop test (TBSt). British Journal of Visual Impairment, 34(1), 72–82. https://doi.org/10.1177/0264619615612344

Jati, S. K., & Mahardika, G. P. (n.d.). Rancang Bangun Aplikasi Pembelajaran Arab Braille Dengan Pendekatan UCD.

Johnstone, C. J., & Thurlow, M. L. (2012). Statewide Testing of Reading and Possible Implications for Students With Disabilities. Journal of Special Education, 46(1), 17–25. https://doi.org/10.1177/0022466910371984

Laroche, L., Labbé, C. A., Benoît, C., St-Pierre-Lussier, F., & Wittich, W. (2017). Current use of contracted and uncontracted french braille in Quebec. British Journal of Visual Impairment, 35(3), 232–246. https://doi.org/10.1177/0264619617711731

Matuszewski, J., Kossowski, B., Bola, Ł., Banaszkiewicz, A., Paplińska, M., Gyger, L., Kherif, F., Szwed, M., Frackowiak, R. S., Jednoróg, K., Draganski, B., & Marchewka, A. (2021). Brain plasticity dynamics during tactile Braille learning in sighted subjects: Multi-contrast MRI approach. NeuroImage, 227(December 2020). https://doi.org/10.1016/j.neuroimage.2020.117613

Nahlisa, R. M., & Christiani, L. (2015). BUKU BRAILE SEBAGAI JEMBATAN KETERBATASAN AKSES INFORMASI SISWA TUNANETRA SEKOLAH LUAR BIASA BAGIAN A DRIA ADI SEMARANG. Jurnal

Ilmu Perpustakaan, 4(2).

Pring, L. (1982). Phonological and tactual coding of Braille by blind children. British Journal of Psychology, 73(3), 351–359. https://doi.org/10.1111/j.2044-8295.1982.tb01817.x

Purnamayanti, A., & Putri, A. T. U. (2020). Strategi Peningkatan Minat Baca Kelompok Tunanetra melalui Media Audiobook. Anuva, 4(1), 109–117.

Putnam, B. C., & Tiger, J. H. (2015). Teaching braille letters, numerals, punctuation, and contractions to sighted individuals. Journal of Applied Behavior Analysis, 48(2), 466–471. https://doi.org/10.1002/jaba.202

Putra, M. R., & Risdoyok. (2021). TAHAP PENGGUNAAN MEDIA BRAIL TEXT BAGI SISWA TUNANETRA DALAM PEMBELAJARAN AL-QUR ' AN DI. AL-TARBIYAH, 31(2), 181–191. https://doi.org/10.24235/ath.v

Rączy, K., Czarnecka, M., Zaremba, D., Izdebska, K., Paplińska, M., Hesselmann, G., Knops, A., & Szwed, M. (2020). A shared code for Braille and Arabic digits revealed by cross-modal priming in sighted Braille readers. Acta Psychologica, 202(November 2019). https://doi.org/10.1016/j.actpsy.2019.102960

Rudiyati, S. (2005). Pengembangan Materi dan Alat Bantu Pembelajaran Anak Tunanetra di Sekolah Terpadu/Inklusi. Jurnal Pendidikan Khusus, 1(2), 87–103.

Ruwah, N., Husnul, I., & Masitoh, L. F. (2021). PENGEMBANGAN BUKU BRAILLE STATISTIK DASAR PADA PROGRAM STUDI TEKNIK INFORMATIKA DI UNIVERSITAS PAMULANG DEVELOPING. Jurnal Sains Dan Matematika Unpam, 3(2), 89–98.

Sanandita, A. D. (2020). Pengembangan media denta braille dalam pengenalan aksara jawa untuk tunanetra milb budi asih semarang.

Scheithauer, M. C., & Tiger, J. H. (2012). a Computer-Based Program To Teach Braille Reading To Sighted Individuals. Journal of Applied Behavior Analysis, 45(2), 315–327. https://doi.org/10.1901/jaba.2012.45-315

Śmiechowska-Petrovskij, E., & Kilian, M. (2016). RoboBraille as a UDL Tool: Evaluation of the Service Converting Printed Materials into Speech and Braille in Poland. Procedia - Social and Behavioral Sciences, 228(June), 335–340. https://doi.org/10.1016/j.sbspro.2016.07.050

Subagya. (2017). Design of Mathematics Audiobooks for Students With. European Journal of Special Education Research, 2(6), 113–123. https://doi.org/10.5281/zenodo.1040678

Sulviyani, I., Novamizanti, L., & Atmaja, R. D. (2017). Perancangan Konversi Braille Ke Teks Berbasis Android.

Tang, J. (2013). Using ontology and RFID to develop a new Chinese Braille learning platform for blind students. Expert Systems with Applications, 40(8), 2817–2827. https://doi.org/10.1016/j.eswa.2012.11.023

Tarigan, D., & Tarigan, H. G. (1987). Teknik Pengajaran Keterampilan Berbahasa. Angkasa.

Tarigan, H. G. (1981). Berbicara. Angkasa.

Tarigan, H. G. (1987). Membaca Sebagai Suatu Keterampilan Berbahasa. Angkasa.

Triyanto, & Rudiyati, S. (2017). PENGEMBANGAN MODUL PEMBELAJARANAKSARA JAWA "DINTA SWARA" DALAM HURUF BRAILLE UNTUK SISWA TUNANETRA. Jurnal Pembangunan Pendidikan: Fondasi Dan Aplikasi, 5(2), 176–186.

Veispak, A., Boets, B., & Ghesquière, P. (2012). Parallel versus sequential processing in print and braille reading. Research in Developmental Disabilities, 33(6), 2153–2163. https://doi.org/10.1016/j.ridd.2012.06.012