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CONCEPTUAL UNDERSTANDING OF CIRCLE ELEMENTS FOR VISUAL IMPAIRMENT STUDENTS: OPTIMIZATION OF SOUND AND TACTILE FEATURES IN CIRCLE BOX LEARNING MEDIA

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ABSTRACT

This study explores the conceptual understanding of visually impaired students regarding circle elements using a learning tool called the Circle Box, which incorporates auditory and tactile features to help students identify circle elements and facilitate subsequent learning. A qualitative naturalistic approach was employed, involving five 8th-grade visually impaired students and two mathematics teachers at a special school in Cimahi. Data were collected through observations, interviews, and a test adapted from Adding It Up: Helping Children Learn Mathematics by the National Research Council. Data were analyzed through reduction, descriptive presentation, verification, and conclusion. The results show that most students successfully identified circle elements and understood key relationships, though challenges remain in verbal explanations and generalizations involving unfamiliar vocabulary. Factors such as age, gender, and the level of visual impairment influence understanding, impacting memorization and confidence. Recommendations for improvements emphasize sound quality, simplified language, and enhanced tactile designs for better usability and learning efficiency.

Penelitian ini mengeksplorasi pemahaman konseptual siswa tunanetra mengenai unsur lingkaran menggunakan media pembelajaran, yaitu *Circle Box*, yang menyediakan fitur pendengaran dan perabaan untuk membantu siswa mengidentifikasi unsur lingkaran sebagai prasyarat pembelajaran selanjutnya. Pendekatan naturalistik kualitatif digunakan dan melibatkan lima siswa tunanetra kelas 8 dan dua guru matematika di sebuah sekolah khusus di Kota Cimahi. Data dikumpulkan melalui observasi, wawancara, dan tes yang diadaptasi dari Buku *Adding It Up: Helping Children Learn Mathematics* oleh National Research Council. Data dianalisis melalui reduksi, penyajian dalam bentuk deskriptif, verifikasi, dan kesimpulan. Hasil menunjukkan bahwa sebagian besar siswa berhasil mengidentifikasi unsur lingkaran dan memahami hubungan kunci, meskipun tantangan tetap ada dalam penjelasan verbal dan generalisasi yang melibatkan kosakata yang tidak dikenal. Faktor-faktor seperti usia, jenis kelamin, dan tingkat gangguan penglihatan memengaruhi pemahaman, hafalan, dan kepercayaan diri. Perbaikan media direkomendasikan dengan menekankan kualitas suara, bahasa yang disederhanakan, dan desain taktil yang ditingkatkan untuk kegunaan dan efisiensi pembelajaran.

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INTRODUCTION

Mathematics plays a key role in understanding the world. It is essential for the prosperity of society, as demonstrated by mathematicians such as al-Khawarizmi, Biruni, and Devi. Understanding mathematics is crucial for critical thinking and tackling challenges like dyscalculia (Alisherovich, 2023). In *Principia Mathematica*, it is explained that the foundation of mathematics is built on logic and has universal applications independent of empirical experience (Whitehead & Russell, 1963). This means that the foundation of mathematics is something coherent and can be associated with many things. Within the scope of learning, mathematics can help develop critical and creative thinking skills by involving logical thinking, analysis, and reasoning (Widiani, 2018). Mathematics can also be applied to enhance social skills and develop literacy skills in various contexts, such as understanding graphs, tables, and other data for budgeting, managing finances, and performing mathematical tasks that foster independence in daily activities.

Independence in daily activities must be possessed by everyone, including visually impaired students. However, there are limitations experienced by visually impaired students in supporting empirical experiences, namely sight. This sense affects how students understand mathematical concepts. Complex visual concepts in mathematics often cannot be accessed by visually impaired students, which leads to their underrepresentation in certain fields (Hayes & Proulx, 2023). This limitation can be bridged with various solutions through the educational process. Therefore, to optimize the educational process for students with special needs, Indonesia's National Education System Law mandates that the right to education without discrimination is a right for every citizen, including children with special needs (2003). Thus, Indonesia implements inclusive education, which combines special education provisions with regular education in an integrated education system (Kemendikbud, 2016). It is known that every student has different abilities in the learning process, including those with specific limitations. Therefore, to support these differences, efforts must be made to create appropriate learning facilities for each student.

Learning facilities are essential tools that students need in their learning process to support their success. A study by Febri (2021) shows that learning facilities affect 41.4% of students' success in learning mathematics. These learning facilities, which contribute to success, must be suitable for the students' needs and abilities. Therefore, facilities for visually impaired students also need to be adapted. Research by Wibawa (2018) found that students with visual impairments had lower learning interest because mathematics lessons were typically explained using general methods, such as oral explanations by the teacher. To address this, comparative research involving learning media was conducted. In Wibawa (2018) study, three-dimensional learning media was used, showing improved learning outcomes. Thus, it is shown that learning facilities are important to increase students' interest and attention, especially when they support learning.

Learning media serve as important tools to bridge students' thought processes during the learning experience. For visually impaired students, the learning process needs to involve media that are suitable and functional so that the learning can be effective, efficient, and accessible (Khaeroh et al., 2020). Learning media can take various forms, such as visual, auditory, and tactile media. The development of learning media has also been greatly enhanced by technology. One such technological advancement is the Arduino platform, which helps in creating simple programs. One such program is the creation of an auditory feature aimed at enhancing the hearing ability of visually impaired students. A team that received funding through the Student Creativity Program (PKM) successfully created an innovative learning tool called Circle Box (Rahmatin dkk., 2023). This tool was designed to display elements of a circle, such as radius, diameter, circumference, chord, juring, and tembereng, through auditory features and tactile textures, helping students identify and understand the circle elements. Compared to other media, such as the GeoGebra application, which Dwijayani (2019) showed to enhance problem-solving skills in learning circle elements through visual simulations, Circle Box provides unique auditory and tactile features. These features are especially beneficial for visually impaired students, enabling them to explore and understand mathematical concepts. Studies such as those by Clark-Wilson dkk. (2020) and Gurmu dkk. (2024) have highlighted how technology-based tools tend to focus on visual interactivity, which is a challenge for students with visual impairments. By incorporating non-visual elements, Circle Box helps overcome this barrier, making learning more inclusive and giving students a foundational understanding of circle elements. This understanding is essential as it serves as a prerequisite for subsequent topics, such as finding the area or arc length in eighth-grade mathematics. To calculate an area, students must first be familiar with the related elements of a circle.

This study has the main objective of describing visually impaired students' understanding of circle elements through the optimization of auditory and tactile features in the Circle Box during the learning process. Specifically, this study aims to answer the research question: How can auditory and tactile features improve the understanding of circle elements for visually impaired students? Given that the learning process is dynamic and involves various factors, it is important to consider these elements within the context of this study. According to (Marcone, 2013), unexpected factors often emerge during learning, influencing student engagement and understanding. Furthermore, (Prasertpong dkk., 2023) identify key factors that influence learning for visually impaired students, such as facilitators, media, technology, curriculum, and self-efficacy. Therefore, the expectation of this research is to contribute by informing the design of learning media that optimizes auditory and tactile features, enhancing the understanding of circle elements for visually impaired students, and providing valuable insights for developers of learning media for visually impaired students.

METHOD

Exploring the understanding of circle elements in students with visual impairments is a case that is not formally formulated. This is because the learning process is full of surprises, and therefore, this study was designed with a naturalistic approach. According to Freeman dkk. (2022), a naturalistic study involves observing subjects in their natural environment without manipulation or control by the researcher. This approach aims to gather authentic data, enhancing the relevance and robustness of findings, as emphasized in the paper's focus on triangulation.

Detailed data was collected involving five students and two mathematics teachers. The students, given pseudonyms, were Tono (13 years old), Kiki (13 years old), Bagas (12 years old), Mawar (14 years old), and Lisa (16 years old). Despite their varying ages, they were all in the same class, which was 8th grade at a special school in Cimahi, West Java, Indonesia. Their visual impairments varied, with three of them, Tono, Kiki, and Bagas, having partial vision impairment (low vision), while two students, Mawar and Lisa, were completely blind. In this study, two teachers, Mr. Yana and Mrs. Rosa, were also involved to complete the data at various stages of data collection. Both teachers also have visual impairments.

Data collection started with an initial observation to explore the culture and learning habits of visually impaired students at the special school, supported by documentation to understand the completeness of learning tools and educational services already in place. During this first phase of data collection, interview guidelines and checklists were used as research instruments. Then, data collection continued with classroom observations. This process involved activities using the Circle Box learning media, which is shown in Figure 1. The instruments used for the second phase of data collection were observation guidelines and tests stored in image and sound recordings.

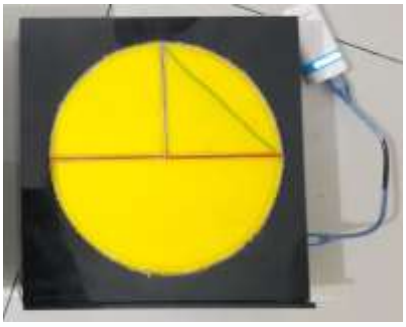

Figure 1. Circle Box Learning Media

Circle Box is a learning tool supported by an Arduino program, powered by electricity supplied through a power bank. This media includes textures that form circle elements, allowing students to recognize the shapes and parts of these elements through touch. When the surface of the media is pressed, it provides explanations through pre-programmed sounds. A single click will announce the name of the element; a double click will provide the definition of the element; and holding it for a few seconds will give an explanation of the symbol of the element (this feature is available only for the radius and diameter of the circle). During the observation, the Circle Box will be used alternately by the students. After using the Circle Box, the activity is followed by a test to assess the depth of the information students gained from using the Circle Box.

The purpose of this test is to evaluate the students' ability to: name at least five elements of a circle; explain the characteristics of the radius, chord, diameter, juring, and tembereng; describe the relationship between the radius and diameter of a circle, and between the arc and circumference of a circle; distinguish between juring and tembereng; and differentiate between the radius and chord of the circle. According to Cahani dalam Khairunnisa et al., (2022), explaining a concept, using it in different situations, and developing some consequences from a concept are dimensions of mathematical conceptual understanding. The indicators of conceptual understanding are adapted from the book *Adding It Up: Helping Children Learn Mathematics* by the National Research Council (Kilpatrick dkk., 2001). The instruments used in this study were designed to meet these dimensions, created by the researchers and validated by experts. In line with Creswell (2016), researchers serve as human instruments who determine the focus of the research, select subjects as data sources, collect data, assess data validity, analyze data, interpret data, and make conclusions from the findings. The test was conducted orally and involved: 1) Questions and answers, and 2) Identifying circle elements through tactile features on the media.

Data collection ended with interviews to confirm the data collected earlier. The interviews involved two mathematics teachers, Mr. Yana and Mrs. Rosa. The interview guidelines contained various questions about the teachers' opinions after using the Circle Box and trying its features. The goal was to gather feedback on the strengths, weaknesses, and suggestions for future development of the learning media for visually impaired students. After data collection, the data processing stage began.

Data processing started with data reduction. In this phase, data that were irrelevant to the focus of the study were selected. Next, the data were presented. In qualitative research, data are presented descriptively. To help identify the students with partial or total visual impairments in writing, "(P)" was used for students with partial visual impairments (low vision), and "(T)" for totally blind students. The final stage of data analysis is verification and conclusion drawing. Initial assumptions and conclusions expressed earlier are tentative. After being analyzed and verified, changes may occur. At this stage, valid data will be presented as evidence based on the findings to create credible conclusions. This is the process of analyzing (processing) the collected data.

RESULTS AND DISCUSSION

Result

School and Student Conditions. This data was collected through initial observations aimed at evaluating the facilities and preparation for teaching and learning activities. Data were gathered directly through interviews, observations, and a review of several documents. The findings of the study show that teaching tools, such as lesson plans (RPP), syllabi, annual programs, and student development potential data, have been organized and used in the learning process. The data on student development potential is used to channel students' abilities through general education services, such as skills, arts, and sports. For visually impaired students, vocational activities such as Massage Training and ICT were provided. Other facilities for visually impaired students include specialized courses such as Orientation Mobility, Social Skills, and Communication (OMSK). This course is conducted in beginner classes or equivalent to grades I, II, and III, as part of special education services, including programs for reading and writing in Braille, training in the use of white canes, orientation and mobility training, and visual/functional sight exercises. These are some of the programs and services available at the school. However, no data was found showing the use of learning media in teaching and learning activities.

Information on learning media was obtained through a discussion with Mrs. Rosa, the 8th-grade mathematics teacher and homeroom teacher. Mrs. Rosa explained that teaching for visually impaired students is clearly different from teaching for students without disabilities. Based on Mrs. Rosa's experience, mathematics teaching in the field of geometry starts with the use of concrete objects, such as using coins to introduce the shape of a circle. Then, verbal explanations are provided. Mrs. Rosa also confirmed that no specific learning media were used for teaching the circle element topic. However, in general, students remained enthusiastic about learning mathematics even though they had not yet mastered the elements of the circle.

Students' Understanding of Circle Elements with Visual Impairments. After the initial observations, data collection continued with classroom observations of the learning activities. This process took place over two sessions. Five students were involved: Tono (P), Kiki (P), Bagas (P), Mawar (T), and Lisa (T). The initial activity ran smoothly, with students paying attention to the explanation of the purpose and stages of the activity. As the core activity began, students who were already familiar with the shape of the circle participated. The activity continued with students using the Circle Box in turn. The students' responses and behaviors when using the Circle Box are shown in Table 1.

Tabel 1. Students' Attitudes and Responses to Using the Circle Box

No	Name	Description
1	Tono (P)	• Gave a concrete example of the arc, using an arrow. He clearly remembered the "chord." • Took the initiative to double-click to hear both the name and definition of the circle element.
2	Kiki (P)	• Has a strong memory and could memorize the elements after hearing it once. • Felt awkward and shy when feeling the media.
3	Bagas (P)	• Slightly shy. • Not very focused due to some hearing issues.
4	Mawar(T)	• Strong memory. • Confident enough to ask questions about other parts of the media.
5	Lisa (T)	• Understood the elements quickly after hearing the definitions. • Still felt awkward when feeling the media due to fear.

The activity of using the Circle Box was carried out alternately. The Circle Box was placed in front of the students. Under the supervision and guidance of the researcher, students were given the freedom to explore the media. As shown in Table 1, some students were still shy and hesitant, which affected the information they absorbed. However, some students maximized their memory when asked to review the information they obtained. The review process was used to assess the understanding the students gained. To validate this, after using the Circle Box learning media, the observation continued with a test. Table 2 summarizes the test results of the students.

After answering several questions on the test, students' answers are summarized in Table 2. Based on the dimensions outlined, students succeeded in achieving the first dimension, which is the ability to name the circle elements. However, two of the five students were still unable to mention all five elements. The second dimension, which pertains to the characteristics of the radius and chord, was understood by two students, but most struggled to explain the chord. Regarding the relationship between the radius and diameter, students tended to answer correctly. When it came to distinguishing between juring and tembereng, and between arc and circumference, students could differentiate between them based on their shapes, but had difficulty explaining them verbally, particularly when formulating sentences.

Tabel 2. Students' Test Results

Name	Mentioned 5 Circle Elements	Explained Characte-ristics of Radius, Diameter, and Chord	Explained Relationship Between Radius and Diameter	Distinguish-ed Arc and Circumfere nce	Distingu-ished Chord and Radius	Distinguish-ed Juring and Tembereng
Tono (P)	Successfu-lly mentioned 5 elements correctly	Accurately explained the characteris tics of	Well understood that the radius is half of the diameter	Could distinguish clearly but lacked complete information	Clearly distingu-ished between chord	Understood the difference between juring and tembereng

		these three elements			and radius	
Kiki (P)	Successfully mentioned 5 elements with assistance	Good at explaining but confused about the chord	Understood that the radius is half the diameter	Correctly distinguished but confused about the center point	Fairly good, but lacked detail	Adequately distinguish-ed, but with some confusion
Bagas (P)	Mentioned only 3 elements	Not confident in explaining the chord	Did not correctly compare elements	Struggled to distinguish	Could not explain clearly	Could not distinguish accurately
Mawar (T)	Successfu-lly mentioned 5 elements	Well explained and gave correct answers	Accurately explained the relationship	Understood the difference between arc and circumference	Could distinguish accurately	Successfu-lly distinguish-ed the difference between juring and tembereng
Lisa (T)	Mentioned 4 elements	Struggled to explain the chord	Stated that the radius was shorter than the diameter	Confused when distinguish-ing	Could not explain the difference between chord and radius	Struggled with the distinction

The use of the Circle Box as a learning tool showed that students had an easier time understanding the linear elements of a circle, such as the radius, diameter, and chord, as represented in the media. The line structure presented in the media helped them recognize and distinguish between these elements more easily. However, when dealing with area-based elements like the juring and tembereng, students faced difficulties in understanding that these elements have areas. This was due to the lack of significant texture differences between the lines and the areas in the learning media, making it challenging for them to distinguish the boundaries of these elements based on texture alone.

Additionally, students tended to focus on the size of the shapes provided in the learning media. For example, the tembereng was made smaller in size, while the juring was made larger, leading students to the incorrect conclusion that "tembereng are always small" and "juring are always large." This indicates that their understanding was still influenced by the visual presentation of the media rather than by the actual definitions.

Several terms in the circle element material also remained unfamiliar to the students. For instance, the term "tembereng," which was sometimes referred to as "tembeng," caused confusion in understanding and memorizing the concept. Another challenge arose from the utilization of audio elements in the learning media. The surface of the elements did not fully produce sound, which led to students occasionally misinterpreting the shapes they were feeling because the sounds produced did not align with their expectations. Even the sound used to announce certain terms, such as "tembereng," was not clear enough for some students, making it difficult for them to associate the sound with the concept it represented.

Aside from the audio aspects, lengthy descriptions and the use of unfamiliar vocabulary in the material also posed a challenge for students. They struggled to comprehend the information provided, which affected their ability to express their understanding of the concepts. Overall, students' understanding of the material heavily depended on their memory skills. If a student had a weak memory, their understanding of the learned concepts was less optimal. These findings suggest that the effectiveness of the Circle Box as a learning tool can still be improved by refining the texture, audio, and presentation methods to make the material easier for students to comprehend.

Opinions on the Circle Box Learning Media. Based on the findings collected, the use of the Circle Box needs to be improved to become a more effective guide. Additionally, it is important to guide students in taking notes. Despite the challenges in using the Circle Box, there are positive aspects of using this media. Students expressed enjoyment, supported by an interview with Mrs. Rosa, who stated that the media was "good and very inspiring." Therefore, it is hoped that the Circle Box can continue to be developed so that it can be more optimal in its use.

From a physical perspective, the Circle Box is relatively heavy due to its construction with 5mm acrylic. Mr. Yana suggested that the media would be better suited for display purposes, like a globe. To optimize the functionality of the Circle Box for visually impaired students, attention must be paid to the material used and its size. This is an effort to avoid the complexities of using the media. Aside from the drawbacks, both Mrs. Rosa and Mr. Yana mentioned that the media has advantages, such as making it easier to understand the definition of circle elements without the need for a dictionary, Google, or books.

Figure 2. Students Using the Circle Box

Figure 2 shows students exploring circle elements using the Circle Box. Kiki (above) experiences partial vision impairment and thus tries to focus on the media carefully, while Lisa (below) maximizes her sense of touch as she is completely blind.

Discussion

Enthusiastic students must be supported in achieving the principles of learning mathematics. According to Runtukahu (1998), there are 7 fundamental principles in learning mathematics, namely: learning mathematics meaningfully; learning mathematics as part of the developmental process; mathematics as a well-structured knowledge; students need to actively engage in learning; students need to know what they are learning in mathematics class; communication between students and educators; and the use of various forms or models of mathematics. These principles apply to all students, including visually impaired students. Indeed, tools must be provided for visually impaired students during learning (Ryanti, 2013). Furthermore, understanding the learning objectives can influence the choice of teaching methods, which should also take into account student performance (Suhendra, 2022)**.** The decision to introduce the concept of circle elements before moving to the material for calculating the area of juring and arc lengths was a planned objective in the learning design. Thus, with the features of the Circle Box, visually impaired students are expected to achieve the learning objectives.

In the data collection, it was found that there is data on the students' potential for self-development. This data is not publicly accessible, so the only aspects that can be reviewed are the differences in age, gender, and the type of visual impairment of the students involved (as explained in the methodology section). Based on the data obtained, students in the same grade level had various ages. Of course, the development of each individual differs, influenced by age, gender, and the type of visual impairment. Individual differences among students certainly exist (Turhusna &; Solatun, 2020). This formed the basis for planning the sequence of usage, starting with male students. Male students were prioritized because female students are generally calmer. All the male students were also students with partial visual impairments (low vision). With this condition, their vision still functions adequately. In general, according to Hallahan & Kauffman (2006), from an educational perspective, there are two groups of visual impairments: 1) Children in the academic blindness category (educationally blind). This group struggles with learning printed letters and the program focuses on optimizing other senses besides vision; and 2) Children with low vision. This group has moderate vision, ranging from 20/70 to 20/200 or a field of vision of less than 20 degrees (normal sharpness). The program for this group aims to optimize the remaining vision.

The differences in visual impairments above clearly influence the learning process. From the answers provided, students with low vision performed better than those with total blindness. When asked to explain certain questions like "What are the characteristics...?" or "What is the difference between...?", students indeed required significant effort. Tono (P) and Mawar (T) took the initiative to find answers through the Circle Box media. Occasionally, Lisa (T) also did this. Kiki (P), aided by his good memory, did not seek information through the media, and Bagas (P) tended to remain passive (silent) when he did not know the answer.

From the students' answers, it was identified that they faced difficulties in redefining the information they obtained about the elements of the circle. Terms like "center" and "edge" and "big" and "small" were words that students understood and used to answer questions. For example, when asked, "What are the characteristics of the radius of a circle?", the answer was, "From the center to the edge of the circle." In the Circle Box, it is explained as "A line connecting the center point of the circle (center) to any point on the circumference of the circle (edge of the circle)." Similarly, when asked, "What is the difference between juring and tembereng?" The Circle Box depicted the juring as a larger area compared to the tembereng. Additionally, students were still unfamiliar with understanding terms like point, line, and area. The ability to understand words, sentences, concepts, questions, and follow instructions is part of receptive language skills. Blind children tend to be passive in communication. If students remain silent when explanations are given, completing tasks becomes difficult (Handoyo, 2016). This is a factor that causes incomplete sentences when students are asked to explain or describe an element because they are less active when directly trying the media, resulting in a lack of interaction.

Learning media is not the primary support in gauging the depth of understanding for visually impaired students. During the trial process, several students showed quite good memory skills, such as Kiki (P) and Mawar (T). In terms of age, they are within the expected range for eighth-grade students, 13 and 14 years old. Gender differences seem to have an effect. Since the Circle Box was facilitated by a female teacher, Kiki, a male student, was more shy compared to Mawar (T). A significant influence occurred in the students' psychological learning factors due to gender differences (Munawarah, 2021). It is explained that students' psychological learning factors are related to the achievements in the learning process, where students with better psychological conditions will produce more satisfactory results. Thus, it is true that Mawar's ability to remember was better than Kiki's.

Another factor is self-confidence. During the test, the Circle Box was placed in front of the students in an active state. The test was conducted orally. There were no restrictions, and no guidance was given on using the media to answer. On several occasions, Tono (P) was confused when answering questions, but he took the initiative to search for answers through the media. Kiki (P), with his good memory, was still able to attempt answers, although some were incorrect. He also consistently refrained from using the media. Another student, Bagas (P), remained silent when he could not answer. Among the three low vision students, Bagas, being the youngest at 12 years old, had less self-confidence, which could affect his learning experience. In contrast, Mawar and Lisa, students with total visual impairments, showed higher self-confidence. Therefore, age is not the primary factor in boosting self-confidence during the use of the Circle Box. Furthermore, self-confidence is influenced by background. As stated in the study by Auliya dan Nurdibyanandar (2020), background and parental roles play a significant role in influencing cognitive development, motivation, affective levels, and selection. Limited access to writing this article has meant that information regarding the students' backgrounds and their parents' roles could not be explained.

Visually impaired children generally rely more on tactile and auditory information to understand the world compared to normal children. The challenges they face are overcome through their hearing and tactile abilities (Desiningrum, 2016). Even during the use of the Circle Box, several challenges were identified, such as students being shy or hesitant in exploring the media. This led to less thorough tactile exploration. For students with partial vision who still have some ability to see, exploring the media was easier because they could identify boundaries and areas involved. Widayati (2013) explains that low vision combined with good tactile abilities helps children achieve 51% recognition of flat shapes, such as circles and squares; differences in size, such as large, small, long, and short; as well as various textures such as rough, smooth, hard, and soft. Therefore, to ensure that students with total blindness are well accommodated, the selection of materials that optimize tactile function and sensitivity must be considered in the creation of learning media for visually impaired students.

The Circle Box was created to bridge the introduction of circle elements using its auditory and tactile features. As explained earlier, there are several shortcomings in the tactile features. The audio features also need improvement. The sound volume has been maximized, but using the media in a classroom with distractions from other students' conversations also affects its effectiveness. Descriptions that are too long and the use of vocabulary unfamiliar to the students create obstacles in understanding. However, terms like "point," "line," and "area" should have already been learned. Additionally, some of the element names are hard to remember, some because their names are similar, such as "arc" and "chord." Others are difficult due to unfamiliar names, such as "tembereng." These issues highlight that students' prior knowledge also needs to be strengthened to help them understand the explanations provided by the Circle Box.

Finally, simplifying the long descriptions in the Circle Box is also necessary to facilitate better understanding.

Overall, the findings of this study show that the conceptual understanding indicators discussed in the methodology were achieved by the majority of students. The students who performed the best were Tono (P), Mawar (T), and Kiki (P). For Lisa (T) and Bagas (P), additional support is needed to achieve full understanding of several complex circle concepts, particularly distinguishing between elements like the arc, circumference, radius, chord, juring, and tembereng. The findings and discussion above provide an overview of the learning process using the Circle Box for visually impaired students. The Circle Box, with all its strengths and weaknesses, is also influenced by various factors to support optimized learning. With the Arduino platform representing the technological advancements that have been applied, there is a wide opportunity for further development of learning media. For instance, in Pakistan, where individuals with disabilities are isolated and facilities are limited, young people are more eager to use assistive technology (Saleem & Sajjad, 2016).

The research findings reveal that there is promising scope for assistive technology as modern assistive technology education and training can be widely accessed (Behrmann & Schaff, 2001). Most blind youth, for rehabilitation purposes, higher education achievements, and securing good jobs, are forced to rely on technology (Siddiqui, 2004). Currently, it is observed that visually impaired students and teachers are very active and enthusiastic in using appropriate modern technology for their training, education, and daily lives (Rockoff, 2004). This shows the promising aspects of assistive technology and its natural progression based on the numerous roles and impacts it has on the lives of visually impaired individuals (Alves dkk., 2009). Thus, current limitations can still be improved, especially as technology continues to develop.

CONCLUSION

The presence of the Circle Box as a learning tool for visually impaired students in learning circle elements, equipped with Arduino to program the sound features and designed with tactile textures on its surface, is not yet perfect but has shown positive responses from students for learning mathematics, particularly in learning circle elements. This study indicates that, predominantly, students have the ability to understand the material, and the indicators of understanding were achieved by the majority of students, although the use of language in presenting the material did not fully align with precise terminology. Nevertheless, the direction of the explanation was close to correct. Through the achievement of the established indicators, students were able to mention more than four elements, provide explanations of circle elements using familiar vocabulary, and identify the relationships between related elements. The Circle Box also made it easier to understand the definitions of circle elements, as these were provided through verbal explanations. This is one of the advantages of the Circle Box. However, its shortcomings include: the descriptions are too long and use vocabulary unfamiliar to visually impaired students; the textures do not clearly differentiate between lines and areas; and the size of the media is large, making it difficult for students to handle. In the learning process using the Circle Box, both intrinsic and extrinsic factors play a role. Extrinsic factors relate to the planning and process of teaching. While the planning was done well, the implementation in the classroom faced challenges, including the less conducive classroom environment and the limited number of Circle Boxes, which caused student focus to be divided and extended the time needed for implementation. Intrinsic factors relate to the students' conditions, including gender differences, memory abilities, vocabulary, self-confidence, and differences in visual impairments. This study implies that the use of appropriate technology in learning media is crucial to enhancing learning effectiveness for visually impaired students. Optimizing auditory and tactile features is closely related to the selection of vocabulary and materials used in the media. The limitations of the Circle Box require further innovation in its design and features to meet the specific needs of visually impaired students. Therefore, it is recommended to pay attention to the materials used in the creation of learning media, ensuring the comfort of users, leveraging more suitable technology, and further developing the Circle Box. This includes improving the descriptions, texture clarity, audio quality, and size to make the media more practical for use

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