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Learning mathematics outcomes using Android for blind students based on Newman's theory

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ABSTRACT

Blind students exclusively use braille materials for teaching math. Teaching tools that assist blind students' motor and hearing nerves are essential for learning. This study was to describe learning mathematics outcomes for blind students after using teaching material for Android devices based on Newman's theory. This research was a case study of blind students. Blind junior high school students from special schools for visual impairment—extraordinary schools in Bandar Lampung, extraordinary schools in Cimahi, and Madrasah Tsanawiyah with special education in Yogyakarta—contributed to the study's subjects. The study employed questionnaires and test questions as research instruments for both teachers and students. The results of this study demonstrate that learning mathematics outcame blind students' after using teaching material with Android apps based on Newman's theory, specifically: i) reading errors: students can understand the information in the questions; ii) comprehension errors: students do not write down things that are known and asked; and iii) transformation errors: students write down the mathematical model (formula) used; iv) skill errors: students can do calculations correctly; and v) coding errors: students do not write conclusions. The average score of the blind students' results using braille was higher than that of the Android application.

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1. INTRODUCTION

Students with disabilities who want to learn at school need skill development programmes and teacher support to become more independent. The programme offered necessitates both internal and external school parties' participation [1]. Learning mathematics can aid kids in developing their problem-solving, calculation, analysis, and comprehending skills. In order to enable pupils to develop their thinking skills, mathematics instruction must be planned and organized [2]. This viewpoint shows that pupils must have the capacity to reason in order to examine and solve mathematical difficulties. Students frequently take a passive approach to learning mathematics. Due to the fact that each student has a distinct level of participation in the learning process, the teacher can offer accommodations according to students' condition [3]. The existence of these differences in student abilities can cause differences in the difficulties obtained by students in learning mathematics. In general, understanding the difficulties in the questions and altering the form of the grammatical abstract that will be employed are the two challenges that students frequently face when learning mathematics.

The problems that students encounter in solving math problems are: difficult to read text and questions, misinterpret the problem, guess the answer to the problem, don't want to find a solution, and can't interpret it in the form of symbols and formulas [4]. To be able to solve mathematical problems, students must get used to practicing their analytical skills so that they can apply formulas and find solutions. Student errors when given a mathematical problem are misunderstanding, transformation and process skills [5]. Children with unique needs, such as blind kids, experience challenges with math learning just as much as regular students do. Blind students learn numbers and calculations in mathematics much like sighted students do. The goal of math instruction for blind children is to enable them to master addition, subtraction, multiplication, and division calculations as well as the concepts of size, distance, and number [6]. Demonstrate that children with limited eyesight also learn the same concepts and content as other students when studying mathematics.

A unique instructional strategy that considers the conditions and traits of poor vision children is required. Learning mathematics has traditionally relied solely on sight. Students with impaired vision may become less motivated and interested in learning as a result. Learning compatibility that enables additional sensory capacities is required [7]. Using instructional resources that include learning media is one of the learning designs for blind pupils. The teacher employs a variety of materials to help students learn math, including bricks, cubes, beads, an abacus, and other shapes. Students who are blind require extra time and effort to comprehend mathematical ideas [8]. Blind students need a learning design that supports their motor nerves. Blind students usually use braille textbooks according to their needs.

Building blocks for space are one of the elements used in mathematics education. Teachers frequently struggle to explain the notion of spatial construction materials to blind students because they cannot understand the contour of the environment being examined. The use of spatial media in braille instructional materials is particularly beneficial for pupils and meets the demands of students with limited vision. Students must be taught the geometry notion as it pertains to learning mathematics in a variety of ways. The representation of the geometric shapes studied requires understanding and observation in order to be understood by students [9]. Teachers need to be able to represent the geometry of the areas examined using a variety of approaches or media. Because it supports their motor neurons, spatial form representation is crucial for students with limited vision. Students who are blind require unique and engaging learning resources. Students who are blind can still use their other senses, such as hearing and touch, in addition to their ability to see. in order for teachers to utilise the senses of touch and hearing when using instructional media [10].

In addition to using spatial media and braille instructional resources, educators also try to stay current with technological advancements. The usage of spatial construction material applications that are suitable for students with low eyesight is a sort of technical progress that may be used. It is simpler for blind students to use their hearing to access information on smartphones. Students who are blind may already use functions on smartphones [11]. Blind students may find it simpler to utilise smartphones for studying because they use voice access, which is facilitated by features on smartphones. The advantages of the android include i) the application is accessible and easy to use with easy-to-understand language and complete material, ii) it makes it easier for students to learn independently because learning material is full audio, iii) it can attract students' attention, and iv) it is easy to access anywhere and anytime [12].

The availability of educational tools with media capabilities can help teachers explain the idea of creating space for pupils with low eyesight. A fascinating alternative to simply using braille teaching materials is the usage of android in education. The talkback app accessible on smartphones substantially aids blind students in using Android. One feature for reading text on a smartphone is talkback [13]. There is a talkback application function on smartphones that can assist blind in using Android.

In this study, braille teaching materials with 3D shapes made from space-building materials were used to teach mathematics to blind students. Students also utilise smartphones that have space construction materials in them. Learning media using pictures is fun and exciting for disabilities students and makes it easier to understand the material [14]. The students are then given problems to solve via 3D braille books and smartphones. Teachers can better students' comprehension and abilities by analysing learning outcomes errors to identify their causes [15]. It is important to examine learning outcomes to comprehend the errors that students commit. Newman's theory will be used to examine these inaccuracies. Newman error analysis is a straightforward diagnostic technique that includes the following: i) reading errors, which occur when students are unable to comprehend the information in the questions; ii) Misunderstandings, which can happen when students are unable to comprehend known and asked problems; iii) Transformation errors, which occur when students make mistakes when converting problems into models (writing formulas); iv) Skill errors, which occur when students perform algebraic calculations incorrectly despite using the right formula; and iv) coding errors, when students cannot show the correct answers or are unable to write conclusions [16].

The novelty of this study is how it describes how blind students' learning results changed after using Android-assisted teaching resources. Blind students now solely use braille instructional materials for

mathematics lessons. As a result of earlier product advancements, it was discovered that android assistance and 3D media for building components were included in braille instructional materials. According to Newman's theory, this study intends to explain the five learning outcomes for mathematics that blind students achieve after utilising android-assisted teaching materials, namely: i) reading, ii) comprehension, iii) transformation, iv) skills, and v) encoding.

2. METHOD

2.1. Design

This research was case study of blind students, and the objective was to get a complete data of blind students in mathematical learning. The information gathered for this study includes descriptive information about learning mathematics outcomes blind students after using teaching material for android devices based on Newman's theory. On the basis of Newman's theory, the study's findings will be examined and presented.

2.2. Subject of the research

The subject of this research was 4 blind students of special schools for visual impairment extraordinary schools in Bandar Lampung, 5 blind students of extraordinary schools in Cimahi, and 4 blind studnets of *Madrasah Tsanawiyah* with special education in Yogyakarta. The selection of research subjects was carried out using the consideration of students who could use braille and smartphone teaching materials. The research subjects used were 4 junior high school students at extraordinary schools in Bandar Lampung, 5 students at extraordinary schools in Cimahi and 4 students at of *Madrasah Tsanawiyah* with special education in Yogyakarta. Purposive sampling was the method employed for subject selection. The choice of research participants was made with consideration towards teachers of pupils with low eyesight.

2.3. Instrument

The instrument used is a questionnaire on the use of mathematics teaching materials for spatial construction, a questionnaire on the use of android applications, and test questions. In the process of filling out the blind student questionnaire, the teacher is assisted by reading each question. Each grade given by the blind student is then written down by the teacher on the student's sheet.

There are 2 instruments in this research, namely a questionnaire and mathematics questions on braille teaching materials and an Android application. Questionnaire used to assess the use of braille teaching materials and Android applications in mathematics learning. Filling out this questionnaire is carried out by students with the help of the teacher.

2.4. Data collecting technique

In this work, braille teaching materials with 3D spatial media and android assistance are used to teach building materials. The following data collection methods using Chose blind student for to be subyek research in junior high school at extraordinary schools in Bandar Lampung, extraordinary schools in Cimahi, and *Madrasah Tsanawiyah* with special education in Yogyakarta. Then, Using braille instructional material with android apps in learning mathematics. In learning, students were asekd to solve problem the exam questions on the instructional materials with Android apps. After the process of finishing the task, there were an information and analyze from the questionnaire student and teacher. Moreover, analyze learning mathematics outcame after using braille material teaching with android apps based on Newman's theory.

2.5. Analysis technique and data validity

The qualitative method lacks systematic criteria that are consistent and standardised. Analytical approaches, such as data collection, documentation, analysis, and interpretation, can be used to improve the reliability of the obtained data [17]. In this study, tables and descriptions of the student learning outcomes based on Newman's theory were utilised as documentation and interpretation strategies for the qualitative data analysis. Source triangulation with the following steps is the data validity technique employed in this study: i) examine the information obtained from written tests and student interviews at the extraordinary schools in Bandar Lampung, ii) examine information from written exams and interviews with extraordinary schools in Cimahi students, iii) examine information from written exams and student interviews at *Madrasah Tsanawiyah* with special education in Yogyakarta, and iv) verifying the information from the analysis.

3. RESULTS AND DISCUSSION

The implementation of blind students' mathematics learning using android teaching materials was carried out in 3 schools. This implementation is applied at extraordinary schools in Bandar Lampung,

extraordinary schools in Cimahi, and *Madrasah Tsanawiyah* with special education in Yogyakarta. Learning activities take place differently in each school. This happened due to the COVID-19 pandemic conditions that occurred in each region. For extraordinary schools in Bandar Lampung and extraordinary schools in Cimahi, learning can take place face-to-face in limited schools. Meanwhile, for *Madrasah Tsanawiyah* with special education in Yogyakarta, learning cannot be carried out in schools so teachers must visit students one by one. For working on the test questions, blind students completed using Braille. The results of this braille work were then converted to alert by field workers. This version of the answer sheet is used as research document data to analyze the learning outcomes of blind students based on Newman's theory.

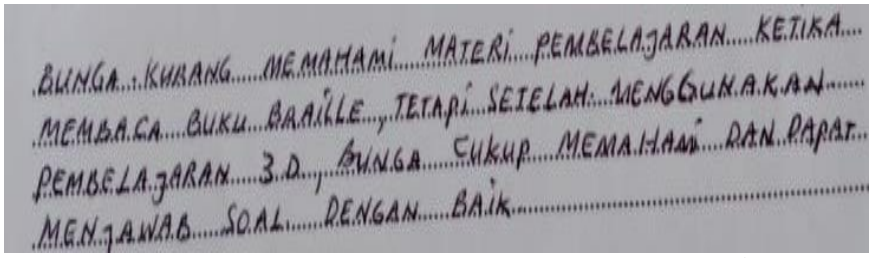
On September 6, 2021, the extraordinary schools in Bandar Lampung began classes. Three days of learning activities with the use of exam questions were conducted using Android teaching resources. At the end of the activity, we gave surveys to teachers and students with low vision. One field worker received assistance while completing the questionnaire for blind students. Students explained that they would understand the material less if they only used braille books. Figure 1 illustrates this explanation clearly.

Figure 1 illustrates how well students can follow instructions and respond to questions after using Android instructional materials. Using the Android application, scores of 76 and 84 were acquired after answering the questions from the teaching materials. There is an increase in the average score of students after using Android for learning. The average value of blind students after using the Android application can be seen in Table 1. The value of utilizing Android teaching resources for blind students at extraordinary schools in Bandar Lampung.

Table 1 shows that using Android teaching materials results in good grades for students. Blind students continued to make mistakes while working on the test questions. In Bandar Lampung's extraordinary schools, we observed blind students making errors during the transformation stages of information into mathematical models. Students can also make mistakes in the calculation process (skill stage). These results can be seen in Figure 2, which is an example of the work done by extraordinary schools in Bandar Lampung.

At extraordinary schools in Bandar Lampung, there were four research subjects blind students. From the results of the data analysis, it is evident that there are differences in student learning outcomes based on Newman's theory. According to Newman's theory, blind students at extraordinary schools in Bandar Lampung achieve the following learning outcomes: i) They can read information on questions clearly; ii) They can write down what is known and asked; iii) They are unable to write mathematical formulas or models; iv) They are unable to perform algebraic calculations correctly; and v) They are unable to write conclusions clearly. The results of this analysis can be seen in Table 2. Student learning results at extraordinary schools in Bandar Lampung based on Newman's theory.

At extraordinary schools in Cimahi, West Java, the second data collection activity was completed. On September 8, 2021, a learning session employing teaching aids for androids kicked off this activity. Five junior high school-aged blind students participated in this activity in a limited face-to-face school. The average value utilising teaching materials is 76, and the average value using the Android application is 72, according to the test question findings. The average score for blind students at extraordinary schools in Cimahi is shown in Table 3.

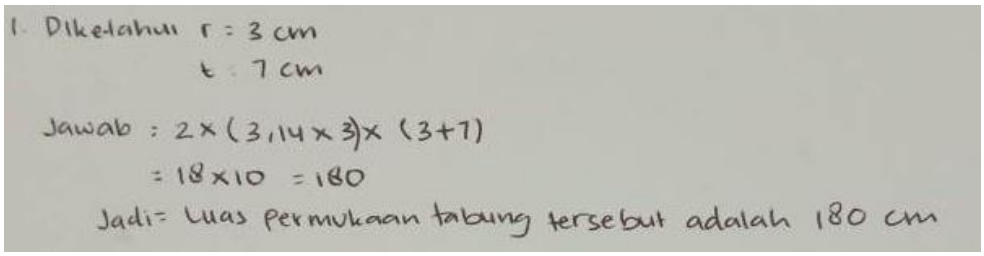


Translation: Students do not understand the material when reading braille books, but after using braille that contains three-dimensional planes, they understand enough and can answer questions well.

Figure 1. Sample of blind student questionnaire results

Table 1. The value of blind students at extraordinary schools in Bandar Lampung

No.	Name	Learning outcomesteaching materials	Learning outcomes Android apps
1.	S1	75	80
2.	S2	70	80
3.	S3	80	90
4.	S4	80	85
Average score		**76**	**84**



Translation:
1. Known:
$r = 3\ cm$
$t = 7\ cm$
Answer:
$2 \times (3.14 \times 3) \times (3 + 7) = 18 \times 10 = 180$
So, area of tube is 180 cm

Figure 2. Sample answer sheet for blind students at extraordinary schools in Bandar Lampung (transformation and skill)

Table 2. Learning outcomes of blind students at extraordinary schools in Bandar Lampung based on Newman's theory

No.	Student	Newman theory				
		Reading	Comprehension	Transformation	Skill	Encoding
1.	S1	Able to understand information	Able to write things known and requested but not fully	Students do not write mathematical formulas/models	Unable to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
2.	S2	Able to understand information	Able to write things known and requested	Students do not write mathematical formulas/models	Unable to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
3.	S3	Able to understand information	Able to write things known and requested but not fully	Students do not write mathematical formulas/models	Unable to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
4.	S4	Able to understand information	Able to write things known but not write requested	Students do not write mathematical formulas/models	Unable to do exact algebraic calculations with correct formulas.	Unable to write a conclusion

Table 3. Recapitulation of the average scores of blind students at extraordinary schools in Cimahi

No.	Name	Average score of teching material	Average score of Andoid apps
1.	S5	90	85
2.	S6	90	85
3.	S7	70	70
4.	S8	80	70
5.	S9	50	50
Average score		**76**	**72**

In extraordinary schools Cimahi, blind students made mistakes in understanding the information in the problem (comprehension). This results in students being unable to change the information in the problem into a correct mathematical model (transformation). This transformation stage error results in students not being able to write the correct answer to the problem given. This explanation can be seen in Figure 3. Sample answer sheet for blind students at extraordinary schools in Cimahi (comprehension, transformation, and encoding).

At extraordinary schools in Cimahi, there were 5 research subjects were blind students. From the results of data analysis, it can be seen that in general students do not make mistakes at the reading stage. Students do not write down the information they know and ask when solving problems. Students also make mistakes at the encoding stage because they cannot write the correct answer. It can be concluded that the learning outcomes of blind students at extraordinary schools in Cimahi are based on Newman's theory, namely: i) students can understand information on questions, ii) students cannot write things that are known and asked, iii) students write mathematical models (formulas) that are used, and iv) can do calculations correctly (but are less systematic and imprecise). The results of the data analysis can be seen in Table 4 learning outcomes of blind students at extraordinary schools in Cimahi based on Newman's theory.

The third place of research was conducted at *Madrasah Tsanawiyah* with special education in Yogyakarta. This data collection was carried out on September 10, 2021. Data collection was carried out by the teacher by visiting 4 students at their respective homes. This is due to the COVID-19 pandemic conditions in local areas which are still quite high. Before working on the existing questions, blind students are first given learning using 3D teaching materials assisted by Android. From the results of using android-assisted teaching materials, data on the learning outcomes of blind students at *Madrasah Tsanawiyah* with special education in Yogyakarta were obtained. demonstrates that using educational materials has a better value than using the Android application does. Utilizing instructional materials has an average rating of 90. While utilising an Android application has an average value of 88.75. Table 5 shown the average score of blind students.

At *Madrasah Tsanawiyah* with special education in Yogyakarta, students were not able to write down the information on the questions. In this case, students make errors at the comprehension stage. Students also cannot write conclusions from the answers they have obtained (stage encoding). These result th sample answers of blind students at *Madrasah Tsanawiyah* with special education in Yogyakarta can be seen at Figure 4. From the answers of 4 blind students, a mathematical error analysis was carried out based on Newman's theory. In general, students can understand the information in the questions but not write it down. Students also do not write conclusions, in this case the encoding stage error. At *Madrasah Tsanawiyah* with special education Yogyakarta, the mistakes of blind students based on Newman's theory are: i) students can understand the information in the questions, ii) students do not write down what they know and are asked, iii) students read the mathematical models (formula) used and some not writing down the formula, iv) being able to do calculations correctly, and v) students not writing down their conclusions. The results of data analysis at *Madrasah Tsanawiyah* with special education Yogyakarta can be seen in Table 6.

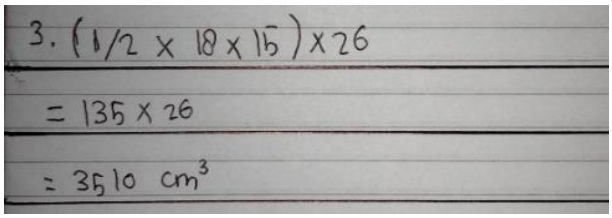


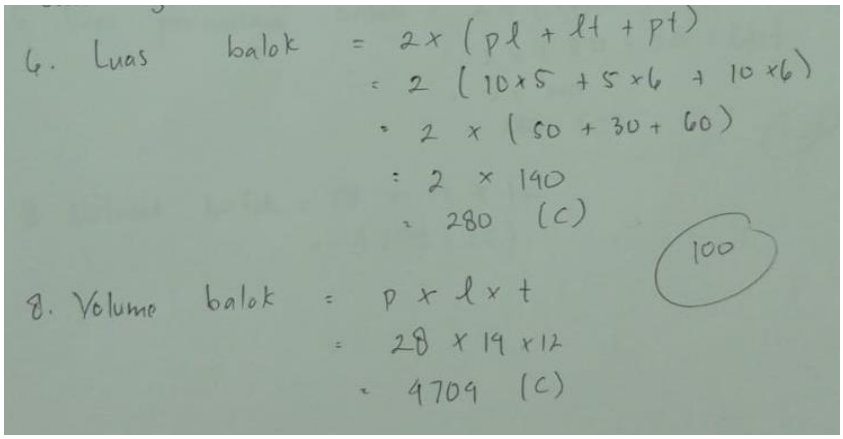
Figure 3. Sample answer sheet for blind students at extraordinary schools in Cimahi (comprehension, transformation, and encoding)

Table 4. Learning outcomes of blind students at extraordinary schools in Cimahi based on Newman's theory

No	Student	Newman's theory				
		Reading	Comprehension	Transformation	Skill	Encoding
1.	S5	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas but not systematic.	Unable to write a conclusion
2.	S6	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas but not systematic.	Unable to write a conclusion
3.	S7	Able to understand information	Unable to write things known and requested	Students do not write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
4.	S8	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas but not systematic.	Unable to write a conclusion
5.	S9	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas but not systematic.	Unable to write a conclusion

Table 5. Average score of blind students at *Madrasah Tsanawiyah* with special education in Yogyakarta

No.	Name	Average score of teaching metrials	Average score of Android apps
1.	S10	90	85
2.	S11	90	90
3.	S12	90	90
4.	S13	90	90
Average score		**90**	**88.75**



Translation:

6. Area of beam:
$= 2 \times (pl + lt + pt)$
$= 2(10 \times 5 + 5 \times 6 + 10 \times 6)$
$= 2 \times 140$
$= 280\ (C)$

8. Volume of beam:
$= p \times l \times t$
$= 28 \times 1 \times 12$
$= 4704\ (C)$

Figure 4. Sample answers of blind students at *Madrasah Tsanawiyah* with special education in Yogyakarta (comprehension and encoding)

Table 6. Learning outcomes of blind students at *Madrasah Tsanawiyah* with special education in Yogyakarta based on Newman's theory

No	Student	Newman's theory				
		Reading	Comprehension	Transformation	Skill	Encoding
1.	S10	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
2.	S11	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
3.	S12	Able to understand information	Unable to write things known and requested	Students do not write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
4.	S13	Able to understand information	Unable to write things known and requested	Students do not write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas.	Unable to write a conclusion

After analyzing data from extraordinary schools in Bandar Lampung, Cimahi, and Madrasah Tsanawiyah with special education Yogyakarta, we can see the types of errors made by blind students using Newman's theory. These types of errors can lead to new discoveries, such as information about blind students' errors when solving mathematical problems. According to Newman's theory, the learning outcomes of blind students after using Android-assisted 3D teaching materials are as follows: i) reading errors: students understand the information in the questions; ii) misunderstandings: students do not write down what is known and asked for; iii) transformation errors: students write down the mathematical model (formula) used; iv) skill errors: students can perform calculations correctly; and v) coding errors: students do not write conclusions. Table 7 shows the mathematics learning outcomes of students who used android teaching materials based on Newman's theory.

Blind students can effectively use Android math teaching resources, and solving arithmetic problems is made simpler. According to the results of student surveys, students feel highly positive about their involvement in the learning process when using Android-assisted 3D mathematics teaching resources. Students' curiosity might be piqued by utilising media from Android applications for learning. Additionally, employing these media for studying is practical and convenient. Students can learn more easily using this portable Android application media [18]. Student learning outcomes after using android teaching materials. Students become more interested in learning by using media-assisted android applications. In addition, this can also be seen from the learning outcomes obtained by students from three places, namely extraordinary schools in Bandar Lampung, extraordinary schools in Cimahi and *Madrasah Tsanawiyah* with special education in Yogyakarta. All students from the three schools received good average scores.

Table 7. Learning outcomes of blind students based on Newman's theory

No.	School	Newman's Theory				
		Reading	Comprehension	Transformation	Skill	Encoding
1.	SLBA in Bandar Lampung	Able to understand information	Able to write things known and requested	Students do not write mathematical formulas/models	Unable to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
2.	SLBA in Cimahi	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas.	Unable to write a conclusion
3.	MTsLB in Yogyakarta	Able to understand information	Unable to write things known and requested	Able to write mathematical formulas/models	Able to do exact algebraic calculations with correct formulas.	Unable to write a conclusion

The use of interactive multimedia when learning mathematics can help students gain a better understanding. The use of interactive multimedia can help students improve their understanding [19]. Android assists with learning through the use of interactive multimedia. Good learning outcomes for blind students at extraordinary schools in Bandar Lampung, Cimahi, and Madrasah Tsanawiyah with special education in Yogyakarta are supported by research results from Nurmawati et al. [19], who found that the use of multimedia can improve students' understanding of mathematics. The use of Android apps as learning tools can help blind students understand more [20]. To improve comprehension, blind students must use audio-enabled applications. The study's findings also revealed that blind students became more aware of building materials after being taught with Android materials.

The learning outcomes for poor vision students at extraordinary schools in Bandar Lampung still contain transformation, skill, and encoding faults. Blind children are typically unable to write the formula needed to answer the questions. Although they can read and comprehend the offered trigonometry problems, the pupils are unable to solve the target problem because they cannot locate the right formula [21]. With indicators able to convert problems into equivalent equations to discover solutions, pupils have not yet mastered the transformation stage [22]. When attempting to solve the given mathematical problems, students commonly make the following mistakes: i) failing to translate the questions into simple terms; ii) Attempting to turn the problem into a mathematical formula; iii) Performing calculations; iv) Manipulating algebra; and v) writing conclusions from solutions [23]. There are similarities with errors that occur in blind students at extraordinary schools in Bandar Lampung, namely transformation and skill errors. Students do not write mathematical formulas/models from the information on the questions.

The miscalculation may cause correct calculation errors. Students who don't write down formulas and mathematical models make more algebraic mistakes. A calculation error prevents students from encoding accurately. Students cannot make accurate inferences. Bandar Lampung's exceptional schools had no reading errors or misunderstandings. Students can write down their knowledge and ask questions after learning the facts. The impact of Newman's theory-based android math teaching materials at Cimahi's top schools on reading errors. Students comprehend the questions. Despite understanding, students don't write down what they know or ask. This can happen if students aren't used to systematic math problem solving. Student math errors include reading and comprehension. Students often draw incorrect information on the problem, misinterpreting it [24]. Students don't use all the information to solve problems. Students also lack experience writing conclusions [25]. Students make understanding errors, like blind students at Cimahi's extraordinary schools. Students use the transformation error indicator correctly. Students can write the proper formula. This good transformation ability helps students calculate correctly. Students no longer make formula errors when calculating. Blind students at this exceptional school in Cimahi write formulas and calculate correctly, but they don't write conclusions. Writing this conclusion is crucial because students can verify their answers.

A mistake occurred in the category of comprehending and encoding errors at Madrasah Tsanawiyah with special education in Yogyakarta as a result of using Android-assisted 3D mathematics teaching materials based on Newman’s theory. Students do not write items that are known and are questioned in the questions when they fall into the category of misunderstanding. Even when there are no reading errors, students struggle to write down what is known and what is being asked in the questions. Students who forget or rush through the questions risk misunderstanding. While errors in the final answer's writing prevent students from making inferences [26]. There are similarities between the mistakes made by blind students at Madrasah Tsanawiyah with special education in Yogyakarta, namely errors in understanding and encoding. Writing down what is known and asked on the question can help students double-check the accuracy of the answers they receive. This misunderstanding is also directly proportional to the number of encoding errors. Students often forget to write a complete conclusion after completing the assigned math problems. However, students make mistakes during the skill process, resulting in incorrect results [27]. Some students make skill errors when solving the questions. Two of the four blind students at Madrasah Tsanawiyah with special

education in Yogyakarta were able to perform well on calculations, while the other two made mistakes in their singing abilities. Students make no mistakes when it comes to transformation errors. In other words, students can accurately write the formula they used. In addition, students do not make mistakes during the skill stage. This is because students can perform correct calculations.

4. CONCLUSION

The aim of this research is to describe the mathematics learning outcomes of blind students using Android based on Newman's theory. Based on the results and discussion, it can be concluded that the results of this study demonstrate that learning mathematics outcame blind students' after using teaching material with android apps based on Newman's theory, specifically: i) reading errors: students can understand the information in the questions, ii) understanding error: students do not write things that are known and asked, iii) transformation errors: students write down the mathematical model (formula) used, iv) skill errors: can do calculations correctly, and v) encoding errors: students do not write conclusions. The average value of learning outcomes for blind students using braille teaching materials is still higher than using android applications.

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