Development of Android-based learning media on trigonometry for 10th graders

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Received: 8 February 2024; Revised: 25 February 2024; Accepted: 2 March 2024

Abstract: One of the main challenges in learning mathematics is bridging students' difficulties in learning abstract material and teachers' weaknesses in presenting the material in an engaging, interactive, and relevant way for students. Technology can be adapted and integrated into mathematics learning activities as an alternative way to overcome these problems. This research aims to develop Android-based learning media on trigonometry material for 10th graders at SMA Negeri 10 Kupang that is valid, practical, and effective. The research and Development (R&D) method with the ADDIE model produced the product. The subject in this study is 10th graders at SMAN 10 Kupang. Interviews, questionaries, and tests were used to collect the data in this research primarily to assess the product's validity, practicality, and effectiveness. The results show that Android-based learning media on trigonometry material is very valid, with an average score of 4.52. The product has also been assessed to be very practical to use by students both in small and large group trials, with the average scores being 4.76 and 4.61, respectively. Android-based learning media is also effective for students learning trigonometry, confirmed by the high percentage of classical completeness in small-group trials (86%) and large-group trials (88%).

Keywords: ADDIE, Android-based learning media, Ispring Suite, Mathematics, Trigonometry

INTRODUCTION

Education can be seen as a process to produce quality human resources. Implementing quality education can guarantee the quality of students and human resources. Concerning the current progressive development, the implementation of education also needs to keep up with it so that the relevance between the human resources produced and the conditions of the world can be maintained. In a micro context, implementing learning in the classroom needs to be aligned with the progressive development of science and technology (Kirana et al., 2023). Learning in the classroom is no longer just an activity of presenting content or material by the teacher. It needs to involve the active participation of students and especially consider the relevance of students’ interests and situations. In this case, integrating technology in learning design and practices can be seen as an effort to accommodate implementing participatory and relevant learning for students.

In learning mathematics, the use of learning media that is relevant to students is essential because mathematics is abstract knowledge and is considered challenging. It must be presented as engaging, interactive, concrete, and relevant for students to understand mathematical concepts more easily (Wahid et al., 2020). Much previous research found that technological-based learning media, specifically Android-based learning media, is effective in mathematics learning both in terms of the learning process and for improving students’...
mathematical understanding and learning achievement (Jihad et al., 2018; Wahid et al., 2020; Widiyatmoko et al., 2021; Yosiana et al., 2021). On the other hand, the utilization of technology-based learning media also leaves many limitations and challenges, namely limited facilities and infrastructures (related to computers, smartphones, electricity, and internet networks), the lack of teachers' knowledge and skills in technology-based media, and the lack of student concentration because they are too busy with their (Guntur et al., 2019; Hidayat et al., 2023).

One of the topics in mathematics is trigonometry, which is very important in learning mathematics because it is related to and becomes the foundation for other materials such as geometry, functions, and calculus (Maknun et al., 2022; Nanmumpuni & Retnawati, 2021). On the other hand, there are still many students who experience difficulties in learning trigonometry with various types and variations of difficulties faced (Fajri & Nida, 2019; Maknun et al., 2022; Nanmumpuni & Retnawati, 2021; Perkasa & Astuti, 2022). Teachers also face many challenges in teaching trigonometry. Maknum et al. (2022) stated that teachers traditionally provide trigonometry content by providing the material procedurally and teaching the definitions, formulas, properties, examples, and exercises. In addition, Spangenberg (2021) also found that many teachers still struggle to teach trigonometry due to their levels of Pedagogical Content Knowledge (PCK).

Low learning outcomes and students' difficulties in learning mathematics can be caused by many factors, originating from the students themselves and outside the students (Siswanto et al., 2023; Udil & Sangur, 2020). One of the fundamental factors is the use and implementation of learning media that is not interesting, interactive, and relevant for students. Teachers' knowledge and skills in planning and designing learning processes that can facilitate students to learn and achieve maximum learning outcomes are essential. This is also related to the teacher's skills in selecting and using appropriate and relevant learning media. Various types of learning media for trigonometry have been studied in previous research. Conventional game-based learning media like "Domino Matematika Trigon" (Sidarta & Yunianta, 2019), "Uno Stacko" (Kusumaningsih et al., 2020), “Roda Matematri" (Angelina et al., 2021) were found to have potential benefits for learning trigonometry. Unfortunately, those learning media have limitations in that they cannot be used repeatedly, are impractical when moving from one class to another, are limited to use in the classroom and depend on the teacher. Technology-based learning media is relevant to current developments and student demands (Rahmida et al., 2023). Previous studies found that technology-based learning media like interactive multimedia-based trigonometry learning media programs (Nurcikawati et al., 2018) and Android-based learning media (Angraini et al., 2022; Kirana et al., 2023; Pujianti et al., 2022; Rizki et al., 2023) is feasible, valid, practical, and effective to use in learning trigonometry.

Unfortunately, learning practices that utilize technology-based learning media are still rarely implemented. The researcher's initial observations and interviews with one of the teachers at SMA Negeri 10 Kupang in February 2023 also indicated that students still had difficulty learning trigonometry material. As stated above, trigonometry is essential foundation material for other mathematics concepts and for enhancing mathematical thinking (Hidayat et al., 2023; Maknun et al., 2022; Nanmumpuni & Retnawati, 2021). Furthermore, the teacher explained that learning on trigonometry material always faces challenges regarding low student participation, conceptual difficulties students face, and teachers' difficulties designing and implementing relevant learning activities. Teachers still do not use relevant learning media, such as technology-based, in their learning practices. It is due to a lack of teacher knowledge and skills to design, develop, and implement technology-based learning media (Ashari et al., 2020; Herawati, 2023; Sahelatua et al., 2018). This ultimately causes learning difficulties for students and learning outcomes that are not optimal. Therefore, the development and implementation of technology-based learning media are essential to follow up on (Herawati, 2023; Sahelatua et al., 2018).
Based on the explanation above, it can be understood that the need to teach trigonometry material with relevant learning media is challenging due to teachers' lack of knowledge and skills in designing and developing appropriate learning media, especially technology-based ones. Android-based learning media is an alternative to solve this problem (Kirana et al., 2023; Nissa et al., 2021; Rahmi et al., 2021). Android is a Linux-based operating system for mobile devices such as smartphones or tablets with open-source characteristics, allowing teachers to create applications that can be used in learning (Apsari & Rizki, 2018). Android has become a widely used operating system (Rizki et al., 2023). Android-based learning media is also considered relatively more straightforward for teachers and students to develop and operationalize in learning. In addition, Android-based learning media can guarantee a more dynamic and flexible learning atmosphere and create a compelling, engaging, and interactive learning process (Auliya et al., 2022).

The development of Android-based learning media is assumed to be suitable to facilitate students studying trigonometry. Therefore, it is essential to develop such a product to help students in SMA Negeri 10 Kupang learn trigonometry in an engaging, interactive, and relevant way. In this study, Android-based learning media was developed using the Ispring suite as a tool. This research aims to develop Android-based learning media on trigonometry material for 10th graders at SMA Negeri 10 Kupang that is valid, practical, and effective. Furthermore, the result of this study hopefully can contribute theoretically and practically to improving the mathematics learning process and students learning achievement, particularly in learning trigonometry material.

METHOD

This research used the Research and Development (R&D) method, which aims to produce or develop a particular product, either a new product or improve existing products, and then test the effectiveness of the product (Sugiyono, 2015). The product developed in this research is an Android-based learning media on trigonometry material. ADDIE model was used in this research consisting of five stages, namely analysis (A), design (D), development (D), implementation (I), and evaluation (E) (Sugiyono, 2015), as shown in Figure 1. The data collection techniques used in this study were (1) interviews, aimed to obtain initial information on mathematics learning, students' characteristics and needs, and teachers' performance; (2) Questionnaires for validation of the product to assess the validity and practicality of the media made by looking to the response of the validator as well as the students; (3) tests, used to measure the ability of students at the end of learning and the effectiveness of learning media used in learning.

![Figure 1. ADDIE Model Stages](image-url)
Analyze Stage

This step gathers initial information regarding students’ characteristics and needs, teachers’ performance, curriculum, and materials as an essential foundation to develop the learning media. Analysis of students’ characteristics and needs aims to find learning media that suit students’ needs. It looks at students’ difficulties in learning trigonometry and their perception of the learning process, especially regarding the use of learning media and the use of the Android mobile phone. It is done through observation and interviews with the students. Teachers’ performance analysis identifies problems and challenges teachers and students face during learning. It is conducted by interviewing teachers about potential challenges faced in the teaching and learning process. This mainly focuses on exploring information about how teachers assess their knowledge, skills, and creativity in implementing engaging, interactive, and relevant learning for students. In addition, it is conducted to find out teachers’ experiences using Android smartphones and technology-based learning media. The curriculum and materials are analyzed to determine the curriculum used in SMA Negeri 10 Kupang. It also aims to find out how the competencies, learning indicators, and materials fit the curriculum and syllabus used in the school.

Design Stage

The design stage consists of two main activities: flowcharts and media designs (storyboards). A flowchart describes the flow from one scene to another and helps researchers understand the navigation structure for developing Android-based media. The initial stage in designing Android-based media is creating a flowchart, which is then used in product development. After making the flowchart, we continued with making storyboards. Storyboards are an initial design for creating Android-based media on trigonometry materials. It involves the design of the background, layout, icons, and material structure.

Development Stage

This stage involves developing the storyboard into an initial Android-based media product and changing the script into a program containing text, images, audio, and video. Firstly, it will be developed using PowerPoint for content (materials) development, and then the Ispring suite will be used for developing final and ready-used learning media. In this stage, expert validation is carried out to assess the validity of the initially developed Android-based learning media. The validity questionnaire contains 15 items on a Likert scale with a five scale. The items are manifested in 3 aspects of validity, namely content eligibility (A1), structure and ease of use (A2), and language (A3). It has to match the validation criteria, as shown in Table 1, before proceeding to the implementation stage.

<table>
<thead>
<tr>
<th>Validation score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 ≤ V &lt; 5</td>
<td>Highly Valid</td>
</tr>
<tr>
<td>3 ≤ V &lt; 4</td>
<td>Valid</td>
</tr>
<tr>
<td>2 ≤ V &lt; 3</td>
<td>Less Valid</td>
</tr>
<tr>
<td>1 ≤ V &lt; 2</td>
<td>Invalid</td>
</tr>
</tbody>
</table>

Table 1. Criteria of validation

To count the validation score, the researcher first counts the average validation score for each aspect $A_i$ by dividing the sum of the validation score of each validator for each aspect $K_j$ by the number of validators ($n$), as shown in Formula 1.

$$A_i = \frac{\sum_{j=1}^{n} K_j}{n}$$  \hspace{1cm} (1)
After that, the researcher counts the validation score ($V$) by dividing the sum of the average of the validation score for each aspect ($A_i$) with the number of aspects ($m$), as shown in Formula 2.

$$V = \frac{\sum_{i=1}^{m} A_i}{m}$$  \hspace{1cm} (2)

**Implementation Stage**

At the implementation stage, the learning media will be experimented and tested on students. Android-based media developed and declared valid is implemented for students at SMA Negeri 10 Kupang class X through small and large-group trials. The subjects in this study were 10th graders of SMA Negeri 10 Kupang in the 2023/2024 academic year. The subjects of the small group trial were XA class students consisting of 7 out of 25 students, who were chosen purposefully and proportionally by considering the heterogeneous abilities of the students. The extensive trial is chosen randomly, and the XB class of 25 students is chosen. In this stage, students in both small and large-group trials are given a questionnaire to assess the practicality of Android-based learning media. The practicality questionnaire contains ten items on a Likert scale with a five scale. The items manifest in 2 aspects of practicality: media (A1) and learning (A3). To count the practicality of the media, the first researcher counts the average practicality score for each aspect ($A_i$) by dividing the sum of the practicality score of each respondent for each element ($K_j$) with the number of respondents ($n$), as shown in Formula 3.

$$A_i = \frac{\sum_{j=1}^{n} K_j}{n}$$  \hspace{1cm} (3)

After that, the researcher counts the practicality score ($P$) by dividing the sum of the average of the practicality score for each aspect ($A_i$) with several elements ($m$), as shown in Formula 4.

$$P = \frac{\sum_{i=1}^{m} A_i}{m}$$  \hspace{1cm} (4)

To evaluate the practicality of the Android-based learning media, it has to match practicality criteria as shown in the following Table 2.

<table>
<thead>
<tr>
<th>Practicality score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4 \leq P &lt; 5$</td>
<td>Highly Practical</td>
</tr>
<tr>
<td>$3 \leq P &lt; 4$</td>
<td>Practical</td>
</tr>
<tr>
<td>$2 \leq P &lt; 3$</td>
<td>Less Practical</td>
</tr>
<tr>
<td>$1 \leq P &lt; 2$</td>
<td>Not Practical</td>
</tr>
</tbody>
</table>

At the end of this stage, students are also tested to assess the effectiveness of Android-based learning media. The test instrument contains 15 questions as an objective test with five choices. All questions are related to the trigonometry material. Students have to achieve a minimum score of 70 to be passed. In addition, the Android-based learning media is effective if classical completeness is equal to or higher than 70%.

**Evaluation Stage**

The evaluation stage is carried out at each stage, starting from the analysis stage to the implementation stage, and revised according to the evaluation results and the unmet needs of the product. Evaluation is not limited to giving a score to the product but mainly to revising and improving the product.
RESULTS AND DISCUSSION

Results

This research and development resulted in an Android-based learning media on trigonometry materials for 10th graders. The product was developed through ADDIE model stages, which can be described as follows.

Analysis Stage

The analysis stage is the initial stage in this research, where the researcher analyzes the needs related to the learning process and learning media used in schools through interviews and the curriculum and materials.

Analysis of Students' Characteristics and Needs

Observation and interviews with students in SMA Negeri 10 Kupang indicated that students struggle to learn mathematics, especially trigonometry. Students also stated that math learning tends to be boring and taught directly. The utilization of learning media still needs to be improved, especially for those who utilize technology. On the other hand, students use Android-based smartphones in their daily lives, but most of them are only limited to social media purposes. Students hope that the learning process can be designed and implemented in a more interesting, interactive, and innovative way. In this case, using Android-based learning media is considered suitable and relevant.

Analysis of Teachers' Performance

Performance analysis is conducted to discover teachers' and students' challenges and problems during the learning process. Based on the interview results, there are limited facilities at school and a lack of teacher creativity in making learning media. Teachers tend to use only textbooks and blackboards as resources and learning media, which makes students not motivated to learn and causes them to have difficulty understanding the material. Teachers are accustomed to operating devices such as laptops and Android-based smartphones. It is just that teachers are not used to developing Android-based learning media products.

Analysis of Curriculum and Materials

The curriculum used at SMA Negeri 10 Kupang is the "Merdeka Belajar" curriculum. The material, competencies, and learning indicators presented in the product developed by the researcher adapt to the curriculum and syllabus used in the school. Mathematics learning materials generally contain abstract concepts with principles and procedures considered difficult, so they require appropriate and exciting learning media so that students do not feel bored in learning and more easily understand the material. Trigonometry material was chosen as the material developed in the Android-based learning media. The material's content is related to concepts and their illustrations, principles, mathematical procedures, examples, and practice problems. This Android-based media can present information or material simultaneously seen, heard, and done through various media such as text, images, audio, and video.

Design Stage

In this stage, two main activities are making flowcharts and making media designs (storyboards).

Making Flowchart

The researcher designed the flowchart to help the navigation structure of developed media. It contains and describes the flow from one display to another. There are eight main menus in the flowchart, namely: instruction menu, profile menu, Pancasila profile menu, indicators, and learning objectives menu, meaningful understanding menu, trigger and prerequisite material.
menu, material menu, and evaluation menu. The complete design of the flowchart can be shown in Figure 2.

![Flowchart of Android-based learning media](image)

### Figure 2. Flowchart of Android-based learning media

**Storyboard**

The researcher continues to design the storyboard after completing the flowchart. It includes activities to design the background, layout, icons, and material structure. The design of the storyboard can be shown in Figure 3.

![Design of storyboard](image)

### Figure 3. Design of storyboard
**Development Stage**

In this stage, the researcher develops Android-based learning media on trigonometry using the Ispring suite. Based on the flowchart and storyboard in the previous stage, it is developed into initial Android-based media products, namely converting scripts into programs that contain text, images, audio, and video. Making this Android-based media consists of 3 steps: product development, expert validation, and product revision. The initial product of Android-based learning media can be shown in Figure 4. The product, in the form of Android-based learning media, is validated by experts to ascertain its validity. The validation results can be seen in Table 3.

**Table 3. Validation result of Android-based learning media**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Validator I</th>
<th>Validator II</th>
<th>Validator III</th>
<th>Average (A_i)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content eligibility</td>
<td>4.5</td>
<td>4.6</td>
<td>4.36</td>
<td>4.49</td>
<td>Highly Valid</td>
</tr>
<tr>
<td>Structure and ease of use</td>
<td>5</td>
<td>4.3</td>
<td>4.33</td>
<td>4.54</td>
<td>Highly Valid</td>
</tr>
<tr>
<td>Language</td>
<td>4.6</td>
<td>4.8</td>
<td>4.2</td>
<td>4.53</td>
<td>Highly Valid</td>
</tr>
<tr>
<td><strong>Average (V)</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>4.52</strong></td>
<td><strong>Highly Valid</strong></td>
</tr>
</tbody>
</table>

Table 3 shows that the average content eligibility aspect (A1) is 4.49, which is highly valid, the average structure and ease of use aspect (A2) is 4.54, which is highly valid, and the average language aspect (A3) is 4.53, which also highly valid. The average validation of the three aspects above is 4.52. Thus, the Android-based learning media on trigonometry is included in the "highly valid" category. Regardless of the validation result, there are comments and suggestions from the validators to revise the initial product. A minor revision of the validator, namely removing the watermark, eliminating the need for information icons, paying attention to the left and proper alignment, and image naming. Based on the comments and suggestions, the researcher revised the initial product.

![Figure 4. Display of developed Android-based learning media](image-url)
Implementation Stage

Android-based media have been developed and validated by experts and then implemented for 10th graders of SMA Negeri 10 Kupang through small and large-group trials.

Small Group Trials

Small group trials were conducted on seven students with heterogeneous abilities. Small class trials are carried out to find out the initial problems before the learning media is implemented in large classes so that errors or deficiencies in the learning media can be corrected. The practicality and effectivity of the media were tested and can be shown in Table 4 and Table 5.

Table 4. The practicality of Android-based learning media on small group trials

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Score</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media</td>
<td>4.8</td>
<td>Highly practical</td>
</tr>
<tr>
<td>Learning</td>
<td>4.71</td>
<td>Highly practical</td>
</tr>
<tr>
<td>Average</td>
<td>4.76</td>
<td>Highly practical</td>
</tr>
</tbody>
</table>

The results in Table 4 show students' assessment related to the practicality of learning media in small group trials. It is known that the total average score is 4.76, with a convenient category. In addition, the product was also found to be highly practical for each aspect, namely the aspect of media (average score of 4.80) and the aspect of the learning process (average score of 4.71).

Table 5. Effectivity of Android-based learning media on small group trials

<table>
<thead>
<tr>
<th>Interval</th>
<th>Frequency</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-69</td>
<td>1</td>
<td>Failed</td>
</tr>
<tr>
<td>70-79</td>
<td>1</td>
<td>Passed</td>
</tr>
<tr>
<td>80-89</td>
<td>3</td>
<td>Passed</td>
</tr>
<tr>
<td>90-99</td>
<td>2</td>
<td>Passed</td>
</tr>
</tbody>
</table>

Table 5 shows the number of students who passed and failed after taking part in learning with the Android-based learning media that has been developed. It can be seen that there is one student who did not pass and six students who passed. Thus, the small class trial shows that the classical completeness is 86%, so the Android-based media can continue to be implemented in the large class trial.

Large Group Trials

The subject of the large group trial was ten graders of SMA Negeri 10 Kupang, consisting of 25 students. The results of the student assessment related to the practicality of the developed Android-based learning media are shown in Table 6.

Table 6. The practicality of Android-based learning media on large group trials

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Score</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media</td>
<td>4.62</td>
<td>Highly practical</td>
</tr>
<tr>
<td>Learning</td>
<td>4.59</td>
<td>Highly practical</td>
</tr>
<tr>
<td>Average</td>
<td>4.61</td>
<td>Highly practical</td>
</tr>
</tbody>
</table>

Table 6 shows the average practicality score of Android-based learning media, 4.75, with a convenient category. When viewed from each assessment aspect, the media aspect obtained an average score of 4.80 and the learning aspect of 4.70, with both categories being convenient. This shows that in the large class trial, Android-based learning media on trigonometry material is considered practical for students, both in the operational context of its use and its benefits in the learning process.
The effectiveness of Android-based learning media on trigonometry materials is shown in Table 7.

**Table 7. Effectivity of Android-based learning media on large group trials**

<table>
<thead>
<tr>
<th>Interval</th>
<th>Frequency</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 - 69</td>
<td>3</td>
<td>Failed</td>
</tr>
<tr>
<td>70 - 79</td>
<td>2</td>
<td>Passed</td>
</tr>
<tr>
<td>80 - 89</td>
<td>11</td>
<td>Passed</td>
</tr>
<tr>
<td>90 - 99</td>
<td>9</td>
<td>Passed</td>
</tr>
</tbody>
</table>

Table 7 shows that three students still need to reach the minimum score to pass. Meanwhile, 22 students reached the minimum score after being taught using Android-based learning media on trigonometry material. This shows that classically, the completeness achieved is 88%. Thus, the Android-based learning media on trigonometry material is effective for class X students of SMA Negeri 10 Kupang.

**Evaluation Stage**

The evaluation aims to determine the quality of Android-based learning media. This evaluation is primarily formative. In this stage, the researcher uses evaluation results to revise and improve the media before applying the final media. After testing the validation score in the development stage, the researcher revised the media based on the validator's suggestions and corrections. Then, the revised product is used in small group trials, and the researcher evaluates the practicality and effectiveness of the media. The researcher uses the result to improve the media to the final and ready-used Android-based learning media. Overall, the researcher revised the Android-based learning media in this stage per the suggestions obtained to produce a good final product.

**Discussion**

This study aims to develop Android-based learning media on trigonometry material that is valid, practical, and effective. The validity of the product is based on expert judgment and validation. Based on the result stated above, the validity of the learning media can be seen from the average validity score by three expert validators, which is 4.52, with a very valid category. Regardless of the validation result, validators also suggest minor revisions to the initial product, such as removing the watermark and not needing information icons, sentence alignment, and image naming. In addition, validators also stated that the initial product is valid in terms of its content eligibility, structure and ease of use, and language used in the product. The trigonometry material in the initial product is considered to be by the syllabus and contains mathematical knowledge that is guaranteed to be correct. In addition, the presented material structure is considered systematic and well-organized, making it easier for teachers and students to use. The language used in the material provided is also considered to be by the standard rules of the Indonesian language so that it can help users properly understand the material's content. This shows that the Android-based learning media on trigonometry material developed by the research is valid for use in the learning process in the classroom both in terms of content substance, structure and ease of use of the media, and the language used. These results are also in line with previous research, which shows the high validity of Android-based learning media (Ashari et al., 2020; Nissa et al., 2021; Rahmida et al., 2023), but differ from this current study, which focuses on trigonometry materials. Previous research also found it is valid to use as learning media on trigonometry materials (Angraini et al., 2022; Kirana et al., 2023; Pujiarti et al., 2022). Angraini et al. (2022) and Pujiarti et al. (2022) developed the Android-based learning media on trigonometry using Adobe Flash CS6, while Kirana et al. (2023) used Smart Apps Creator. Those previous studies differ from this current study in using the spring suite to develop the Android-based learning media on trigonometry material.
In addition to product validity, this study measured product practicality based on student responses when using Android-based learning media on trigonometry material. This research and development results also show the practicality of Android-based learning media on trigonometry material. This can be seen from the average score of the practicality of the learning media developed, namely 4.76 in the small group trial and 4.61 in the large group trial, both of which are in the very practical category. These results show that students assess the products developed as practical to use as learning media while helping to facilitate the learning process on trigonometry material. Regarding Android-based media, students rated the developed product as easy to operate as an application on mobile phones, can be used flexibly in various places and times, the content is read clearly. It can be understood, the color variations, icons, backgrounds are attractive, and the available menus function correctly. As a learning media, students assessed that the developed product could help them understand trigonometry material by presenting organized and clear concepts, complete example problems, and sufficient practice questions. The result of Android-based learning media practicality is by previous research, which found that Android-based learning media offers practicality for students (Apsari & Rizki, 2018; Rahmi et al., 2021) both in the context of its use and to help learn trigonometry material (Angraini et al., 2022; Kirana et al., 2023; Pujiarti et al., 2022). This becomes very important to foster interest, motivation, and ease of learning for students (Auliya et al., 2022).

After the Android-based learning media is developed and implemented in both small and large trial groups, students are tested to reveal the product's effectiveness. The results of this study indicate that Android-based learning media on trigonometry material is effective for 10th-grade students of SMA Negeri 10 Kupang. This can be seen from the achievement of student learning outcomes after being taught using Android-based learning media on trigonometry material. The minimum completeness criteria applied at SMA Negeri 10 Kupang is 70. The results of the evaluation of students using learning media that researchers have developed obtained a percentage of student learning completeness in the small group trial of 86% and a percentage of completeness of learning outcomes in the large group trial of 88%. This confirms that using Android-based learning media on trigonometry material effectively improves student learning outcomes. The effectiveness of Android-based learning media on trigonometry material is in line with student responses regarding the practicality of the learning media. The presentation of Android-based learning media on trigonometry material that is well organized and systematic makes it easier for students to learn trigonometry material. In addition, the illustrations provided in the media make it more relevant and concrete for students to understand the concepts studied. The examples and practice problems also allow students to explore the material studied adequately. These results are in line with several previous studies which found that Android-based learning media are effective (Angraini et al., 2022) in improving students' mathematics learning outcomes (Wahid et al., 2020) and specifically effective in trigonometry material (Rizki et al., 2023). Angraini et al. (2022) found that Android-based learning media on trigonometry material is effective for increasing student learning independence, while in this current study, Android-based learning media on trigonometry material is effective for improving student learning outcomes. Meanwhile, Rizki et al. (2023) found that Android-based learning media developed using Articulate Storyline 3 effectively improved student learning outcomes in trigonometry material, while in this current study, Android-based learning media was developed using the Ispring suite.

Android-based learning media on trigonometry material can be an option for math teachers teaching trigonometry material, which students consider complex and abstract. The results of this study indicate that Android-based learning media on trigonometry materials are valid, practical, and effective for students to implement. This also becomes one of the right choices for teachers to teach mathematics in a relevant and exciting way to students. The results of this study contribute to teacher knowledge related to alternative Android-based learning media. In addition, practical implications are also given from the results of this study related to
the design and implementation of Android-based learning media on trigonometry material for the high school level. In this case, mathematics teachers can consider learning designs integrating Android-based learning media to improve student learning outcomes. In addition, further research related to the utilization of Android-based learning media in mathematics learning can continue to be carried out for other materials and to improve other aspects of mathematical ability.

CONCLUSION

Based on the results of the research and discussion above, it can be concluded that the Android-based learning media on trigonometry material developed by researchers is valid, practical, and effective to be implemented in class X students of SMA Negeri 10 Kupang. The validity of the Android-based learning media developed is reflected in the very valid criteria given by expert validators to the design and initial products developed, both in terms of material substance, structure, ease of use, and language. The practicality of Android-based learning media on trigonometry material can be seen from student responses in both the small and large group trials, which stated that the product was very practical to use. In this case, the Android-based learning media developed is considered very practical by students both in the context of its use and to help learn trigonometry material. In addition, this Android-based learning media has also proven to be effective in classical learning outcomes. This can be seen from the high percentage of students who reached the minimum score determined after being taught with the Android-based learning media.

The research that has been conducted has several limitations. The sample used in this study was relatively small and limited to SMA Negeri 10 Kupang students. In addition, the product's effectiveness was only measured by testing the minimum completeness criteria, so experimentation and statistical tests need to be done in the future. Furthermore, future research related to the utilization of Android-based learning media in mathematics learning can continue to be carried out for other materials and to improve other aspects of mathematical ability.

DECLARATIONS

Author Contribution: NT: Conceptualization, Writing - Original Draft, Editing, and Visualization; JN: Formal Analysis, Methodology, Validation, and Supervision; PU: Writing - Review & Editing, Formal Analysis, and Methodology.

Funding Statement: -

Conflict of Interest: The authors declare no conflict of interest.

Additional Information: Additional information is available for this paper.

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