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Development of Learner Worksheets Assisted by Geogebra Software on Trigonometry Material for Class X

*Mesaluna Rida Hapsari[1], Adi Nurcahyo[2], Muhamad Toyib[3]
[1, 2, 3] Muhammadiyah University of Surakarta
*a410200025@student.ums.ac.id

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ABSTRACT

This study aims to describe the validity, practicality, and effectiveness of trigonometry learning media in improving students' understanding of concepts and skills in mathematics. The development method used is the Research and Development (R&D) method. The model used in this research is the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The results of this study indicate that the validity test results by validators with a total average of 0.75, which means valid because it is in the index $0.4 \leq V \leq 0.8$, which means it has high validity criteria. Then, a paired sample T-test was conducted to determine whether there was a significant difference before and after using the media and the resulting sig. (2-tailed) is 0.000 because of the sig value. <0.05, then H0 is rejected, meaning there is a significant difference between the pre-test and post-test results of students' ability to solve trigonometry material questions. So, it can be concluded that using LKPD assisted by Geogebra Software has proven effective in increasing students' interest in learning and involvement in learning mathematics and increasing students' understanding of trigonometric concepts, making the learning process more exciting and interactive.
Keywords: *Learner Worksheet, Trigonometry, GeoGebra.*

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INTRODUCTION

Education status in Indonesia still needs improvement as it is considered low quality (Setiaputra and Kholid 2023). Currently, mathematics is taught in primary and secondary schools, as it is one of the central sciences students learn (Septiani and Kholid 2023). According to James (Fathurrahman and Fitrah 2023), mathematics is a logical science in form, structure, quantity, and interrelated concepts; the three fields of science that make up this subject are algebra, analysis, and geometry. Math is considered difficult because students encounter many terms and symbols in the learning process and require abstract operations (Celen 2020). On the other hand, mathematics is essential in everyday life because it helps solve problems by applying logical, objective, analytical, critical, and creative thinking (Arhasy and Mulyani 2017).

Based on observations, students need clarification and confidence in solving problems regarding trigonometric material. Teachers often use a lecture learning model, resulting in decreased student activity during learning. According to (Girah 2020), the lecture method is the most traditional teaching method and has long been practiced in education. This method is sometimes boring, so it requires certain media so that the delivery is not boring and can attract students' attention. This significantly impacts student learning outcomes, especially for trigonometry material. This is in line with the opinion of (Nurhayati 2017), who said that until now, students still need help understanding mathematics subject matter, especially trigonometry. Meanwhile, there needs to be practical teaching material from the teacher to support learning trigonometric functions. This hurts the learning process because what they learn may not be meaningful.

Trigonometry is material related to height and distance, completion of right triangles, analysis of sine, cosine, and tangent functions, measurement of angles in various measures (degrees and radians), trigonometric proof, and other related subjects (Dhungana, Pant, and Dahal 2023). Trigonometry is important to learn because many concepts are developed from branches of mathematics to facilitate humans in solving everyday problems regarding the fields of construction, music, and economics (Ishartono, Juniati, and Lukito 2016). Researchers are interested in using LKPD to develop interactive learning media related to trigonometry material. According to (Umbaryati 2016), Learner worksheets are a means to assist and facilitate the learning process in the classroom so that there is effective interaction between students and teachers. This can improve students' activities, achievements, and learning outcomes. This is the opinion (Nurliawaty et al. 2017) that utilizing LKPD learning media can serve as an alternative to improve student learning outcomes.

In addition to using LKPD, teachers need an application that can facilitate and assist the learning process in the classroom. *GeoGebra* is an application that allows students to understand learning concepts actively. *GeoGebra* is dynamic math software for geometry, algebra, and calculus that can help teachers teach math (Sappaile et al. 2023). According to (Nurcahyo et al. 2021), *GeoGebra* can be accessed online from the website, and *GeoGebra* can also be installed on a computer. *GeoGebra* is one of the simple applications that can help teachers improve their mathematics teaching. Utilizing *GeoGebra* to teach or learn mathematics is an efficient way to learn

and can help improve skills in geometry, algebra, and calculus (Hutkemri and Akmar Syed Zamri 2016). In line with research conducted by (Pavethira and Leong 2017) shows that the use of *GeoGebra* has a significant impact on improving students' abilities in the learning process. *GeoGebra* can be applied to the teaching and learning process, allowing students to explore concepts in more detail to expand their knowledge (Jelatu, Sariyasa, and Made Ardana 2018).

Based on previous research on learning media development, the study results show that *GeoGebra*-assisted project-based learning can significantly impact mathematics teachers. These results can be achieved through project-based learning supported by *GeoGebra*, which allows math teachers to build solid object geometry concepts (definition of solid objects, area, volume geometry), making it easier to develop mathematical knowledge content (Sumarni et al. 2018). Research conducted by (Sumarni, Prayitno, and Nurpalah 2017) said that improved learning outcomes using *GeoGebra*-assisted *learning cycle*-based economic mathematics teaching materials were better than students whose learning did not use *GeoGebra*-assisted *learning cycle*-based economic mathematics teaching materials. In addition, research (Novitasari et al. 2021) concluded that the LKPD developed with a *GeoGebra*-based scientific approach was proven effective in improving students' concept understanding. There is also research (Nurmeidina, Lazwardi, and Nugroho 2021) concluded that the existence of learning modules could have a positive impact on the modules produced, namely making it easier for students to understand the content of the material, become interested in learning trigonometry and making it easier for students to learn and practice independently. Based on previous research, learning modules can be an excellent solution to improve students' abilities, especially problem-solving skills. Previously, when studying trigonometric functions, the modules provided at school were sometimes not used. Therefore, it is necessary to develop learning media. The advantages of the learning media developed in this study are learning media for students in the form of Student Worksheets assisted by *GeoGebra Software* on Trigonometry material, especially on the topic of trigonometric comparisons at right triangle angles and unique angles to help students understand the material and be able to develop problem-solving skills from the exercises given. In this learning media, there is primary trigonometry material along with examples of problems and practice problems that students must solve and equipped with instructions for use and links to access with *GeoGebra*. This learning media is efficient because it can be used anywhere and anytime and can be accessed with a *Handphone* or *Laptop*. This can make it easier for students when learning takes place because when learning takes place, they feel they do not understand it, but they can learn independently by accessing this learning media using a *HandPhone*.

Thus, the objectives of this development research are (1) to Produce learning media for students that are valid, practical, and effective and (2) to Describe the validity, practicality, and effectiveness of learning media to improve students' understanding of concepts and skills in mathematics subjects, especially trigonometry material.

METHOD

The research method used is research and development (R&D). According to Sugiyono (2021), the research and development method is used to develop specific products and test their effectiveness. The product created in this research is *GeoGebra*-assisted LKPD.

The ADDIE research model consists of five steps: analysis, design, development, implementation, and evaluation (Weldami and Yogica 2023). The purpose of choosing the ADDIE model for this development is because the ADDIE model is a development model that pays attention to essential details about the development of educational products. This model can adapt to technology, learner needs, and content and can be used to develop various types of products, including the development of teaching materials (Safitri and Aziz 2022).

This research includes five stages: (1) The analysis stage includes analyzing the material to be used and the applicable curriculum and applied at school. (2) The design stage includes determining the elements and materials to be included in the LKPD; (3) The development stage includes developing learning media, preparing equipment, and validating learning materials and media. The initial results of this learning media were tested for validation against validators, which aims to determine the level of validity of the media developed to be used as trigonometry learning materials. The validation sheet was used as a data collection tool during the material validation process. All data collected as part of the validation process is analyzed qualitatively and quantitatively; (4) Implementation stage, including trials, namely testing of teaching materials. The teaching materials developed in this research are technology-based in the form of documents. The structure contained in this learning media is based on school trigonometry material because GeoGebra Software supports this learner worksheet learning media, which is equipped with links that users can access; (5) The evaluation stage includes students directed to work on questions contained in the LKPD, which aims to measure the achievement of LKPD development based on the results of trials on students after using LKPD.

The subjects of this study were students of class X AKL 2 SMKN 1 Banyudono, which amounted to 36 students. This study used research instruments such as documentation, observation, *GeoGebra*-assisted LKPD, and questionnaires to collect data. The LKPD instrument is used to test the feasibility and effectiveness of LKPD on students. The questionnaire consists of a questionnaire sheet for validation of material experts and media experts.

The data analysis techniques used were descriptive, qualitative, and quantitative. Qualitative data from comments and suggestions from validators were described qualitatively as a reference for improving the LKPD. Quantitative data in the form of expert assessment scores from material and media experts are characterized quantitatively using a four-point Likert scale and then described qualitatively (Nopitria, Agus Susanta, and Irwan Koto 2022). Moreover, the trial's results on students were analyzed using the normality test and statistical analysis of the *paired sample t-test*.

RESULTS AND DISCUSSION

The model used in this research is the ADDIE model, which consists of five phases: Analysis, Design,

Development, Implementation, and Evaluation. There is an explanation of the results of the five phases, namely:

Analysis

Based on the results of observations of mathematics learning that have been done. The teacher's teaching method still uses the lecture method, namely how to teach by only using oral and whiteboard media assistance, which can make students bored and less interested in learning. The utilization of LKPD learning media development assisted by *GeoGebra Software* is appropriate for classroom learning. This is the opinion (Simbolon 2020), that *GeoGebra* functions is a mathematics learning media that can help students understand abstract mathematics material visually. Meanwhile, according to Nurcahyo (2020), teachers can use *GeoGebra* as an alternative learning media. Mastery of *GoeGebra* allows teachers to teach material accurately and measurably. This will help learners understand the material.

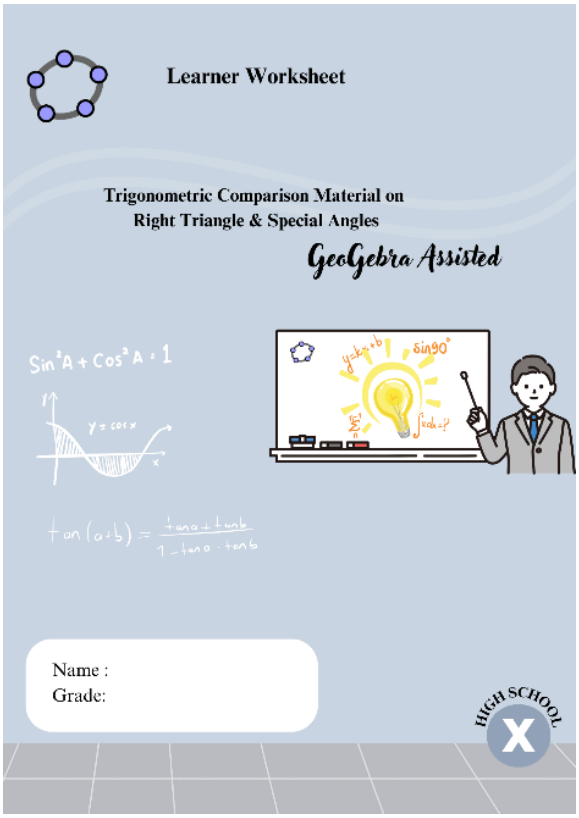

Figure 1. Cover page of LKPD

This study used the material used in mathematics subjects at the SMA / SMK level. Therefore, the material chosen is trigonometric. The selection of this material is based on its suitability for the *GeoGebra* application (Ishartono et al. 2022). Furthermore, the analysis carried out is curriculum analysis to ensure that the learning media developed is by the applicable curriculum and applied at school.

Design

Based on the analysis conducted, an initial product design was produced. This stage begins with determining the elements contained in the LKPD and then proceeds to collect learning materials and practice questions to be done in the LKPD. The selection of trigonometric function material based on trigonometric comparison in right triangles and unique angles is compiled based on references from several sources. At this stage, the researcher begins to design the LKPD using Canva. Creative skills are needed in preparing LKPD, which researchers must master so that LKPD looks good and motivates students to read and study it. This stage also makes material and media expert validation sheets to obtain validity, effectiveness, and practicality data.

Development

At this stage of development, researchers develop a learning media framework design that has been made. The product developed in this study is LKPD, a mathematics learning media that contains learning material for

trigonometric functions, especially trigonometric comparisons of right triangles and unique angles. This stage is carried out to create LKPDs that students can use. The following is an image of the LKPD cover page (Figure 1).

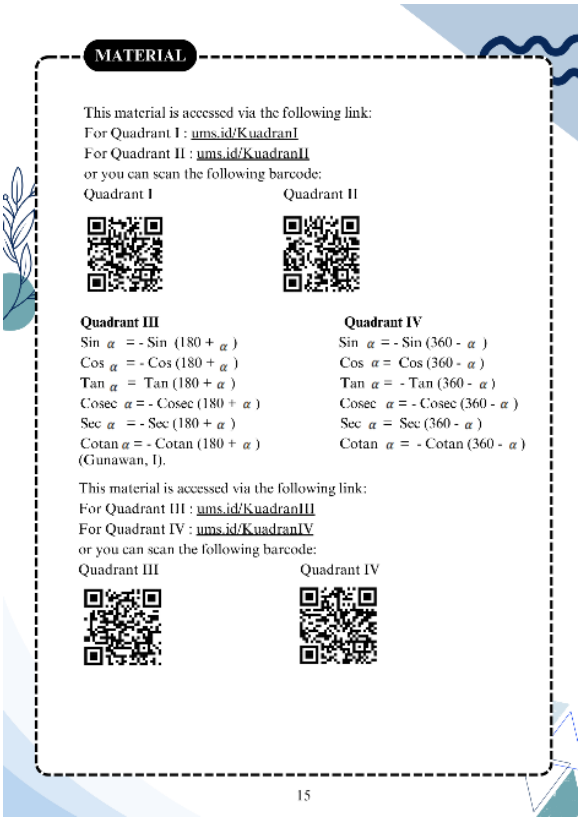

Figure 2. Elements of LKPD page

LKPD is also equipped with elements that must be contained in LKPD, namely learning achievement indicators, initial competencies, Pancasila student profiles, and so on. Here is one picture of a page that contains elements on LKPD (Figure 2).

In addition, the material contained in each LKPD is equipped with a *GeoGebra* link, which teachers and students can then access. Here is one picture of the material page equipped with a *GeoGebra* link (Figure 3).

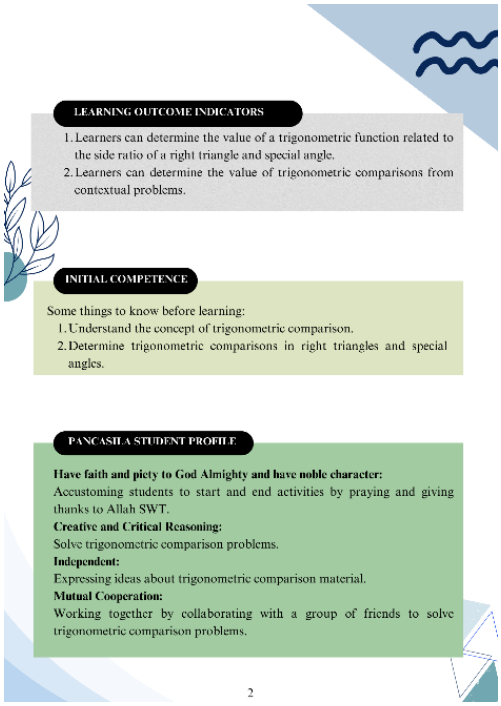

Figure 3. Material Page Equipped with *GeoGebra* Link

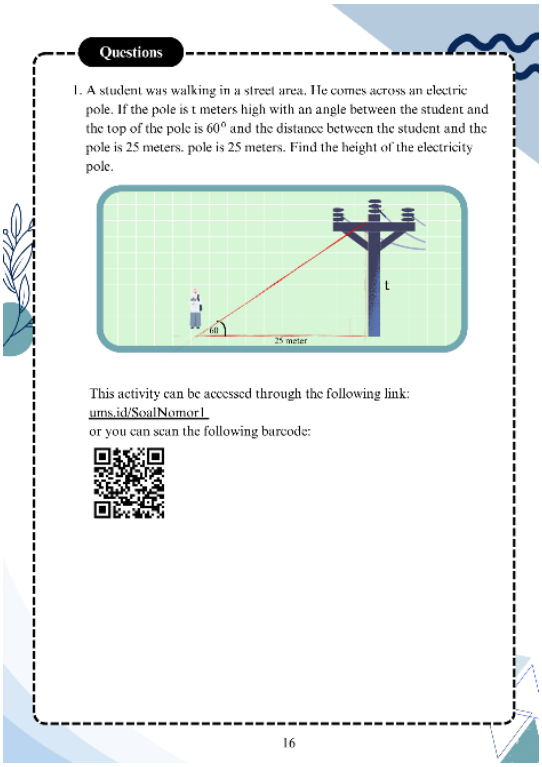

Figure 4. Question page

In the last section, an evaluation is carried out, which includes questions designed to improve students' ability to solve contextual problems related to trigonometric functions, with the topic of trigonometric comparison of right triangles and particular angles equipped with *GeoGebra* links. Here is one picture of the question page (Figure 4).

The next activity at this development stage is the Validation of *GeoGebra software*-assisted student worksheets. A validator carries out the validation process to determine the validity of the developed *GeoGebra software*-assisted LKPD. According to Sappaile (2023), Validation is carried out to obtain feasibility assessments, suggestions, and input from experts to ensure that the developed LKPD is effectively feasible to use. Aspects of Validation include (1) the suitability of learning media with the material used and (2) the suitability of learning media with the learning process in the classroom (Ishartono et al. 2022).

After validation by the validator, the developed product was deemed suitable for revision. There are various comments, suggestions, or inputs from validators to improve the quality of the products developed. The validator's suggestions or input on the material are

1. Consideration of the time to use LKPD,
2. Examples of problems are lacking, and
3. The pictures on the exercise questions are not appropriate.

Meanwhile, there are suggestions or input from the validator on the media, namely (1) *GeoGebra* display is too monotonous, and (2) Add page numbers on LKPD.

Table 1. Material and Media Expert Values

Assessment Aspect	Average	Description
Material Aspects	0.79	Valid
Construction Aspect	0.78	Valid
Media Aspect	0.67	Valid
Average total assessment	0.75	Valid

Based on the results in Table 1, the average value of the validity of LKPD is 0.75. When viewed with the Aiken's Value index validity criteria, this value is included in the "Valid" category because it is in the index $0.4 \leq V \leq 0.8$, which means it has a high level of validity. This means that the validator provides a consistent assessment, and the developed media is suitable for learning.

Implementation

The learning media developed has been tested against validators. After researchers test the validity by using validation data, they improve the media so that it is suitable for use by students. The next stage is to conduct field trials with students. The application is intended to test the effectiveness of the product. The researchers involved 36 SMKN 1 Banyudono Class X AKL 2 students at this stage. The field trial was conducted in two meetings. The first meeting discussed trigonometric definition and comparison material from unique angles. Meanwhile, the second meeting discussed the material of trigonometric comparison of angles in various quadrants until working on problems.

During the field trial, students conducted several classroom activities guided by the researcher. According to Payadnya (2023), this activity is divided into four steps as follows:

1. Introduction of Learning Media LKPD and *GeoGebra*: In the field trial, the first step is introducing LKPD and *GeoGebra* learning media to students. This introduction aims to inform and familiarize them with new learning media.
2. Classroom Activities: After introducing learning media, learners engage in various classroom activities guided by researchers. This activity is carried out to utilize LKPD learning media as a learning resource effectively.
3. Researcher support: Throughout the field trial, the researcher actively supported and guided learners while using the learning media. This support ensured that learners could understand the effective use of the learning media. The researcher also facilitated discussions about the learning media used.
4. Evaluation: After the field trial, learners were asked to re-evaluate the materials. This evaluation helps researchers measure the media's effectiveness in improving students' understanding of mathematical concepts.

Field trial activities are needed from the four steps above to determine how excellent and feasible the media is in helping and supporting the learning process in the classroom.

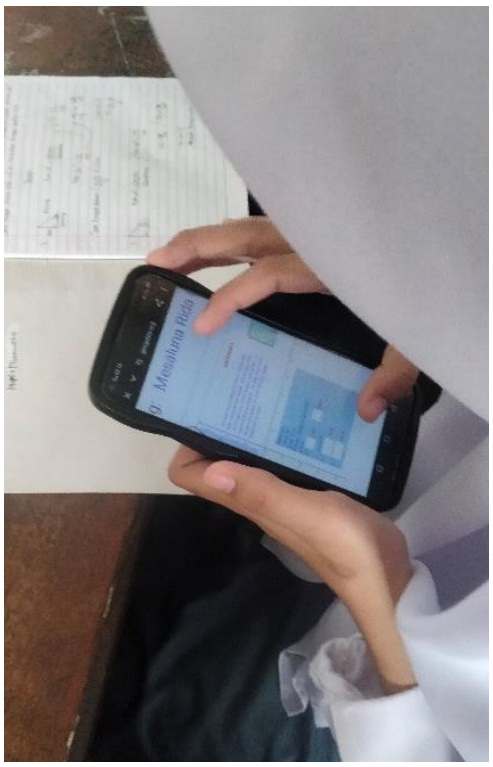

Figure 5. Product Trial to Learners

Figure 6. Product Trial to Learners

After the LKPD was distributed to students, researchers received a positive response. This can be seen from the indicators of each aspect, such as the language and text used, attractive appearance, design, and images, as well as the presentation of activities from easy to difficult. This is by Bruner's theory that learning develops from specific concrete facts towards generalization (Nopitria et al. 2022).

Researchers also obtained trial results, namely that using learning media LKPD assisted by *GeoGebra* can increase students' interest in learning. It is proven that students are enthusiastic about solving problems presented with *GeoGebra*, and *GeoGebra*-assisted student worksheets can also increase their involvement in the learning process. They actively participate in discussions and try to find solutions to the problems posed. This is the opinion (Nurcahyo et al. 2021) that using *GeoGebra* as, an interactive learning media, can assist teachers in increasing

student involvement in learning.

The last stage of this stage is to test the effectiveness of using the product in improving the ability of students to solve trigonometry material problems before and after using the media. This is done through data analysis of pre-test and post-test results. This is by the opinion (Prasetya, Rohana, and Fuadiah 2023) that the effectiveness value is obtained through the learning outcomes test questions distributed after students carry out learning activities using the developed product. The data obtained from the pre-test and post-test results were analyzed using the normality test (N-Gain), homogeneity test, and paired sample t-test for statistical analysis. Based on the analysis conducted using N-Gain, the normality results were obtained as follows:

$$\text{N-Gain} = \frac{Score\ post\ test - Score\ pre\ test}{Score\ ideal - Score\ pre\ test}$$

$$\text{N-Gain} = \frac{85-59}{100-59}$$

$$\text{N-Gain} = 0.63$$

Based on the calculation results, it is known that the normality obtained through the N-Gain test is 0.63 and is included in the medium criteria. The homogeneity test can be carried out after the research data is usually distributed through the normality test. The homogeneity test determines whether the two population groups are homogeneous or heterogeneous (Aulannisa et al. 2021). To find out whether the data is homogeneous, researchers will also test the data with the help of the SPSS program. Based on the analysis conducted using SPSS with One-Way ANOVA, the homogeneity results are as follows:

Table 2. Data Homogeneity Test

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.133	1	70	.716

Based on the calculation results, it is known that the homogeneity obtained through the One-Way ANOVA test is 0.716. The variance of the data on student learning outcomes is the same or homogeneous. The requirement to conduct a paired sample t-test is that the data used must be normally distributed. As in the basic rules in parametric statistical analysis, the main requirement is that the research data must be normally distributed (Aulannisa et al. 2021). In this study, normality and homogeneity tests have been carried out. The next step is to conduct a paired sample t-test, presented in Table 3.

Table 3. Paired Sample T-test

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pre_Test - Post_Test	-26.194	7.171	1.195	-28.621	-23.768	-21.918	35	.000

Hypothesis:
H_0: No significant difference exists between the *pre-test* and *post-test results* in students' ability to solve trigonometry problems.
H_1: A significant difference exists between the *pre-test* and *post-test results* in students' ability to solve trigonometry problems.

Testing Criteria:
1. Accept H_0 if sig. > 0,05
2. Reject H_0 if sig. < 0,05

Based on Table 3, the Sig. (2-tailed) with $\alpha = 0.05$ is 0.000. So that Sig. <0.05, it can be concluded that H0 is rejected, which means there is a significant difference between the pre-test and post-test results of students' ability to solve trigonometric material problems. This shows that using *GeoGebra*-assisted LKPD learning media is proven effective in improving students' ability to solve trigonometric material problems. According to Suriani and Devita (2021), the effectiveness of LKPD in assessment is to ascertain the extent to which LKPD is valuable and beneficial in improving students' learning outcomes through students' ability to understand concepts and solve math problems.

Evaluation

The evaluation stage is the final stage in ADDIE. The evaluation stage is used to measure the achievement of LKPD development based on the results of LKPD validation and the results of trials on students after using *GeoGebra*-assisted LKPD on trigonometry material (Sappaile et al. 2023). The overall validation of LKPD by validators and the results of trials on students show that LKPD is in the category worth using. The feasibility of the LKPD is further determined from the trial's results on students. Based on the feasibility assessment, researchers have determined that *Geogebra*-assisted LKPD can be applied in the mathematics learning process. Thus, *GeoGebra Software*-based LKPD is valid, practical, and effective. This aligns with research conducted by (Krisnayani, Waluyo, and Suarsana 2019), with the results of *GeoGebra Software*-based LKPD meeting the valid, practical, and effective criteria. In his research, he obtained valid criteria based on validation questionnaires, practical criteria based on student response and teacher response questionnaires on limited trials, and effective criteria measured based on student learning outcomes tests. According to the opinion of Setiawati, Risalah, and Oktaviana (2021) which states that the *GeoGebra*-assisted student worksheet media used has met the criteria of being very valid, efficient, and practical, as evidenced by the results of the validity percentage of 91.62% with very valid criteria, the percentage of practicality of 95.69% and the percentage of effectiveness of 80% with effective criteria. The research conducted by (Prasetya et al. 2023) states that the *GeoGebra*-assisted LKPD of the tangent material of the two circles meets the valid, practical, and effective criteria and is evidenced by the results obtained, namely, the *GeoGebra*-assisted LKPD is declared very valid with a score of 85.33% from the three validators. The assessment results of the students' response questionnaire to the *GeoGebra*-assisted LKPD obtained a score of 90.4%, so it was declared very practical. In the learning outcomes test assessment, 13

out of 15 students achieved completeness ≥ 75 with a percentage of 85.66% with very effective criteria.

CONCLUSION

Based on the results and discussion previously described, a conclusion can be drawn, namely: (1) *GeoGebra*-assisted Learner Worksheets that have been developed are feasible to use for learning mathematics according to validator assessments and student responses; (2) The development of learning media for Learner Worksheets Assisted with *GeoGebra Software* has a positive impact on students' mathematics learning. Suggestions for further research: Develop Learner Worksheets assisted by *GeoGebra Software* for other materials, optimize the use of *GeoGebra*, and increase the variety of questions presented.

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