

Development of E-Worksheets Using Contextual Teaching and Learning to Increase Students' Critical Mathematical Thinking

Lestari Roswahyuliani^{1*}, Radifan Irsaly Ruchiyat¹,
Wawat Mugiawati¹, Wahyu Hidayat¹

¹Mathematics Education Department, IKIP Siliwangi, Indonesia

*Email: lroswahyuliani@gmail.com

Received: 13 July 2023; Revised: 13 March 2024; Accepted: 28 April 2024

Abstract. This study aims to develop e-worksheets using contextual teaching and learning to improve students' critical mathematical thinking. The method used in developing e-worksheets was design research. The research data were obtained through validation questionnaires, student responses, and critical mathematical thinking skills tests. The research subjects used were 36 Year 10 students in one of the public high schools in West Bandung Regency. Based on the results of data analysis, the validation results obtained were 3.6 with valid criteria, and student responses about practicality obtained 'very practical' criteria with an average percentage of 86%. The product's effectiveness is said to be 'Very Good' with an average score of 80.75 from the students' post-test. The increased students' critical thinking resulted in the 'Moderate' criteria with an N-Gain of 0.66. E-worksheets with contextual teaching and learning are feasible and can improve students' critical mathematical thinking skills on the comparison of trigonometric function.

Keywords: contextual teaching and learning, critical mathematical thinking ability, development of e-worksheets

How to cite: Roswahyuliani, L., Ruchiyat, R. I., Mugiawati, W., & Hidayat, W. (2024). Development of e-worksheets using contextual teaching and learning to increase students' critical mathematical thinking. *Jurnal Didaktik Matematika*, 11(1), 139-154. DOI: <https://doi.org/10.24815/jdm.v11i1.33116>

Introduction

Learning mathematics helps students improve their ability to think critically. However, in improving these abilities, there are difficulties that students must face in their learning process. It is the same as the comparison of trigonometric function studied after studying pythagoras and triangles. It is used as one of the conditions for studying three-dimensional matter, limits, functions, and derivatives. Students must comprehend comparative trigonometric material to study other subjects with higher difficulty levels, such as limit, derivative, and integral (Ojmba, Gogo, & Cletus, 2021). Such a study takes a lot of comparative trigonometric material to determine the size of the angle, the comparison of trigonometry in the right triangle, and the value of the special angle in the triangle. Although the comparison of trigonometry is used as a prerequisite for further study, many students who have not yet understood the comparison of trigonometric function when going to study the material later still solve trigonometry problems with the wrong concepts, not even knowing the initial concepts (Sibaen, Buasen, & Alimondo, 2023).

Some reasons for students' mistakes in solving trigonometric comparison problems include (1) identifying, questioning, answering, and drawing conclusions. (2) Students are confused about the use of trigonometry. (3) Students have difficulty understanding the purpose of the questions. (4) When solving problems, students tend to answer quickly and carelessly; they are not accustomed to it and do not think it is necessary to conclude at the end of their answers (Rukman, Zulfikar, & Rahayu, 2023). Therefore, the comparison of trigonometric function emphasizes the need for students to sharpen and enhance their critical mathematical thinking (MCT) skills (Yang & Sianturi, 2017).

According to Jahic and Pilav-Velic (2020), the ability to think critically in mathematics needs to be enhanced because student development focuses on solving problems that can be applied in social, technological, economic, and mathematical contexts. Dvoryatkina, Melnikov, and Savvina (2022) argue that mathematics learning aimed at improving critical mathematical thinking skills will positively impact real life. Good mathematics instruction that applies contextual problems as a foundation will make it easier for students to enhance their critical thinking skills.

Students often avoid learning mathematics because it requires more thinking to be easily understood and applied (Dvoryatkina et al., 2022). Only a few students can systematically understand and solve mathematical problems (Hobri, Arifin, Murtikusuma, Oktavianingtyas, & Putri, 2021; Mulenga & Marbán, 2020). In 2018, PISA results showed that Indonesian student performance had declined and remained relatively low (Tohir, 2019). According to Kurniati, Harimukti, and Jamil (Zulmi & Akhlis, 2020), solving PISA questions falls into the category of high-level thinking, one of which is critical thinking. Various methods have been implemented to improve students' critical mathematical thinking (MCT) skills, especially in the comparison of trigonometric function (Heidari & Ebrahimi, 2016). Worksheets containing problems that invite students' comments and opinions in the problem-solving process, supported by reasons derived from independent thinking and information gathering, can help sharpen students' critical thinking skills (Mahmuzah, Ikhsan, & Yusrizal, 2014; Nugraheny, 2018).

Based on observations made by some teachers, the worksheets used during the learning process face several obstacles, one is that the questions still rely on outdated indicators that have not been updated to align with the current curriculum. This issue arises because teachers often create worksheets once and reuse them in subsequent academic years. As a result, students are trained using outdated methods that do not keep pace with current educational standards, leading to a decline in their cognitive abilities, particularly their critical thinking skills (Yunianta, Herman, Wizhar, & Kurniawan, 2023).

The contextual approach is used to help enhance students' MCT skills because, using a context-based approach, students can provide reasons for their answers in everyday life (Agus, 2019). When solving problems, students can apply and visualize them in daily life. Many students given worksheets with a contextual approach still show low critical thinking skills because the worksheets consist only of questions without any interactive elements. Therefore, it is necessary to develop worksheets that teachers can use as teaching materials for school activities. (Ernawati, 2019). As Yaumi (2018) suggested, the worksheet is a teaching material that needs to be developed by current trends to accelerate students' thinking processes.

Students can use web-based media such as Liveworksheets, which allows them to work on their worksheets anywhere and at any time. This transforms the material into electronic worksheets for students (e-worksheets) (Madden, Sweeney, & Gonzales, 2023). The teacher will provide a link to the e-worksheet for students to use as training or learning material in class on the comparison of trigonometric function. Students will focus on using their phones to work on interactive e-worksheets instead of playing on them during learning. E-worksheets also help students understand trigonometry problems better because they contain various forms of the topic, not just one type of question (Zamzam, Komarayanti, & Mahfud, 2023). Using e-worksheets can help enhance students' critical thinking by requiring them to upload the reasons behind their selected answers when solving trigonometric problems.

There has been some research on developing student worksheets to improve students' ability to think critically about mathematics. Lestari, Prahmana, Chong, and Shahrill (2023) developed realistic mathematics education-based worksheets to improve students' critical thinking skills. Similarly, Kristanti, Ainy, Shoffa, Khabibah, and Amin (2018) conducted development research on creating creative problem-solving worksheets for a transformation geometry course, Nurhidayah and Pratama (2024) conducted research on students' e-worksheets based on the project and character of Pancasila through environmental issues. However, there has been no research on developing students' e-worksheets using contextual approaches to enhance students' critical mathematical thinking skills. Therefore, this current study develops e-worksheets using contextual teaching and learning to improve students' critical mathematical thinking skills. This study aims to measure the validity, practicality, and effectiveness of e-worksheets using a contextual teaching and learning approach to improve students' critical mathematical thinking.

Method

This research focuses on developing e-worksheets using a contextual teaching and learning approach for trigonometry comparison material. This research design is developmental research using a formative evaluation design (Tessmer, 1993), as illustrated in Figure 1.

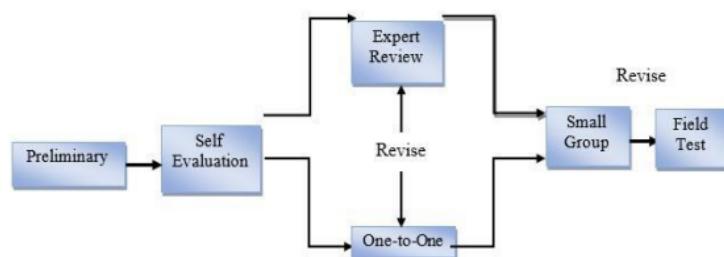


Figure 1. Research design flow

In the preliminary design stage, the researcher determines the location, subjects, and other preparations, such as the instruments to be used and the research schedule, to manage the duration of the research process. This research was conducted at Senior High School 1 Cisarua, West Bandung Regency, West Java Province, in April 2022. The subjects studied were 36 students in class X SMA, with four participating in individual trials, eight in small group trials, and 24 in field trials. The formative evaluation design stage is divided into three phases: self-evaluation, prototyping, and field tests. Each phase is connected to the development process and must be carried out sequentially, as students and experts assess the results from one phase to another.

Self-evaluation focuses on two stages: analysis and design. The analysis stage is the initial phase in the development process. At this stage, the researcher analyzed student criteria, the curriculum used, and the content to be studied. The aspects analyzed include students' abilities, from basic skills like comprehension to higher-order skills like critical thinking. This analysis was conducted to observe students' criteria during the learning process through interviews with one of the teachers involved in the study. A curriculum analysis was also carried out based on core skills, basic skills, and learning indicators used in teaching comparative trigonometry material in high schools.

Furthermore, an analysis was conducted on the source material used to design the product, which is the e-worksheets. In the design stage, researchers created student e-worksheets based on prototypes designed to enhance students' MCT skills in trigonometry comparison material using a contextual approach. In the development process, a prototype focus is necessary to guide each step of the research. Prototyping focuses on four aspects of feasibility, namely: (1) content, (2) presentations, (3) language, and (4) comfort with contextual teaching and learning (Hidayat, Rohaeti, Ginanjar, & Putri, 2022). Prototyping focuses on three stages: expert review, one-on-one, and small group. The purpose of prototyping is to demonstrate the validity and practicality of the product. At this stage, the developed product has been designed and evaluated.

The expert review stage involves practitioners considered experts in mathematics learning, particularly contextual teaching and learning. These practitioners aim to validate the e-worksheet by analyzing its strengths and weaknesses in various aspects. The expert assessment aims to assess, evaluate, and validate whether the e-worksheets developed are valid according to specific

criteria. Based on the expert evaluation, the student worksheets were revised based on comments and suggestions from the experts. The results of the expert validation determine whether the student worksheets are valid. The revision results obtained in Prototype I are referred to as Prototype II. The description of the average score of the validity test data can be seen in Table 1.

Table 1. The average score of validation results

Score	Criteria
$3.33 < \bar{x} \leq 4$	Valid (can be used)
$2.67 < \bar{x} \leq 3.33$	Valid (usable through revisions)
$2 < \bar{x} \leq 2.67$	Not valid (needs revision)
$\bar{x} \leq 2$	Invalid (needs to be replaced)

Source: Ernawati & Sujatmika, 2021

One-to-one is the initial step, where the first development results are trialed on several students separately. This phase runs parallel to the expert review phase, with the revision results from this phase used to improve the student worksheets, leading to Prototype II. The small group phase is part of the development process for expert reviews and is referred to as Prototype II. The experimental results from the one-to-one stage involve several students with different abilities. At this stage, eight students are invited to discuss and undertake to learn about the worksheets developed to get comments and engage with the developed worksheets to provide comments and suggestions. These three stages aim to determine the practicality of the student worksheets. The comments and suggestions from students at the small group level led to further revisions, resulting in Prototype III.

The final stage in this development process is the implementation phase, which involves many students according to the specified subject. Comments from testing Prototype II serve as the basis for revisions to Prototype II. The product tested at the field test stage should be the best according to the criteria. Furthermore, the results of student response data were analyzed through the percentage calculation of student responses to each statement given in the form of a questionnaire. The criteria of practicality based on students' responses are presented in Table 2.

Table 2. The criteria of practicality

Score	Criteria
0.00% -20%	Not practical
20.1%-40%	Less practical
40.1%-60%	Pretty practical
60.1%-80%	Practical
80.1%-100%	Very practical

Source: Arikunto and Suharsimi, 2011

Students worked on critical mathematical thinking skills test questions on the comparison of trigonometric function during the field test. The results obtained from the assessment were then analyzed to determine the effectiveness of the e-worksheets. There are two criteria for effectiveness: the percentage of students who reach the minimum mastery criteria (MMC) in a class (P) and the average N-gain score.

The score of the minimum mastery criteria is 72. The criteria of the percentage of students who reach the minimum mastery criteria in a class (P) is presented in Table 3.

Table 3. The criteria of the percentage of students who reach the MMC

Post-test Score	Criteria
$P > 80$	Very Good
$60 < P \leq 80$	Good
$40 < P \leq 60$	Middle
$20 < P \leq 40$	Lacking
$P \leq 20$	Very lacking

Source: Sugandi and Maya, 2020

The formula of the N-gain score is:

$$N - gain = \frac{Posttest\ score - pretest\ score}{Ideal\ score - pretest\ score}$$

The criteria for the average N-gain score is presented in Table 4.

Table 4. The average of N-gain score criteria

Score	Criteria
$n\text{-gain} > .70$	High
$.30 < n\text{-gain} \leq .70$	Moderate
$n\text{-gain} \leq .30$	Low

Source: Meltzer (Wahyuni, Erman, Sudikan, & Jatmiko, 2020)

The e-worksheets are said to be effective if the percentage of students who reach the minimum mastery criteria is at least in the good criteria and the average n-gain score is at least in the Moderate criteria.

Results and Discussion

The process of developing student worksheets begins with the preliminary design stage. In the preliminary design stage, a preliminary study and analysis are carried out on the subject. A preliminary study was conducted to determine the conditions of students and schools that used them as subjects. Furthermore, the school was observed and analyzed in terms of curriculum, student character, and the material provided to students. This is done so that the products developed can become innovations for schools and can be used for the long term. After the preliminary design was carried out, a design was carried out regarding the student worksheet, which would be developed using a contextual approach to improve students' MCT skills. Researchers also prepare other instruments used during the learning process, such as lesson plans, questionnaires, and test questions to measure students' MCT abilities.

The results obtained in this preliminary design process show differences in the characteristics possessed by students, so some students are grouped as research subjects according to their characteristics. This is aimed at equity in other stages of development. The school uses the 2013 curriculum with a syllabus that is arranged according to the situation of the students at

that time. At this early stage, the researcher prepared the worksheets based on the criteria obtained during the preliminary study to create a worksheet that could impact students' MCT abilities. The e-worksheets are organized according to the sub-chapters of the given material, starting from angle measures, values of comparison of trigonometric function, relationship between angles, and their applications. Then, the e-worksheets were arranged for four meetings according to the sub-chapters of the material given. Worksheets also contain trigonometry comparison material adapted to a contextual approach to positively impact students' MCT skills.

The developed e-worksheets are structured according to a contextual approach that aims to improve students' MCT skills. While developing the e-worksheets-, there were several obstacles in compiling and adjusting to the contextual approach because, at that time, students had just returned to offline school after being carried out online due to COVID-19. So, researchers need to adjust to the circumstances of students who are adapting again to offline schooling. At this early stage, the researcher prepared the e-worksheets based on the criteria obtained during the preliminary study to create a worksheet that could impact students' MCT abilities. E-worksheets are arranged in four meetings on the material to be provided, namely four meetings. E-worksheets also contain the comparison of trigonometric function adapted to a contextual approach to positively impact students' MCT skills. The following is the form of the e-worksheets that have been compiled.

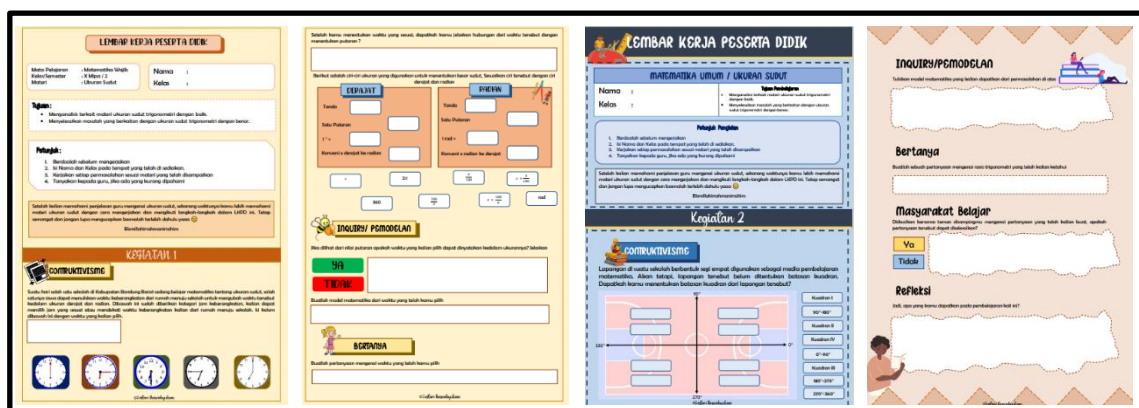


Figure 2. Design e-worksheets

Figure 2. shows the results of the student's e-worksheet design. After the e-worksheets above are completed, a validation test is carried out on validators who are experts in e-worksheets and a contextual approach. The validation test aims to check whether the e-worksheets developed are valid and by the criteria. These results are described in Table 5.

Based on the results in Table 5. It is explained that the score for each aspect almost meets the requirements. Several things need to be revised, and the validator must give suggestions to improve the product being developed. By Table 5, the criteria obtained from the expert validator's assessment results are valid. This proves that I have received expert validation from the e-

worksheets that Prototype has prepared. After the student worksheets with contextual teaching and learning have been revised based on the comments and suggestions provided by the validator, which can be seen in Table 6, the student electronic worksheets using contextual teaching and learning can be considered valid.

Table 5. Expert validation results

Validator	A score of each criterion				Average score sum	Percentage	Criteria
	I	II	III	IV			
I	3.53	3.48	3.54	3	3.45	86.25%	Valid
II	3.5	3.5	3.25	3.5	3.31	82.69%	Valid
III	3.53	3.48	3.25	3.5	3.44	86%	Valid

Based on Table 6, it was found that there were several deficiencies in the product being developed, especially regarding instructions and legibility to students. So, improvements must be made according to expert validation so that students have no difficulties using the developed e-worksheets and feel helped by these e-worksheets.

Table 6. Comment and Suggestions of the experts and researcher's feedback

No	Comments	Revision Decision
1.	Instructions must be given at the constructivist stage to help students conclude concepts independently through problems.	Provide instructions to students on how to convert rounds, degrees, and radians.
2.	At the asking stage, a clue must be given	A question is given as a guide for work, and answers on the e-worksheets
3.	All problems are made based on real problems	All contents of student worksheets are adapted to real problems
4.	Facilitate students in accessing e-worksheets	Students are given a barcode to make accessing electronic worksheets easier.

The next stage is practitioner trials. Student mathematics electronic worksheets based on contextual teaching and learning on the comparison of trigonometric function are said to be practical based on observations during one-to-one trials and small groups. The development of student e-worksheets was tested on three students face-to-face. At the one-to-one stage, students were given the e-worksheets, and then the researcher gave several questions regarding the student's electronic worksheets that had been given. Students provide comments, suggestions, and views on the product being developed. In this process, the student provides some input regarding the e-worksheets he examines. According to the student, the answer box needs to be enlarged because even though the e-worksheets media will automatically be in order, students will feel confused in checking back on the answers they have filled in. After conducting revisions based on student input, small groups were carried out.

Products that have gone through the one-to-one stage will enter the small group stage. Before entering the small group stage, the student's electronic worksheet must go through the revision stages in advance according to comments and suggestions from expert validation and student subjects in the one-to-one stage, the student's electronic worksheet (now Prototype II) can

be tested Try it on eight students at the small group stage. This stage is different from the one-to-one stage. Students are provided with electronic worksheets that have been developed and revised. Then, students try the e-worksheet using e-worksheets during the learning process. Students are asked several questions about the difficulties they face when using e-worksheets using contextual teaching and learning.

Responses and results from small groups can be used in development to improve e-worksheets, and development results in small groups can be said to be Prototype III or the final design phase. Before the e-worksheets were carried out at the field test stage and implemented in the application of MCT skills using contextual teaching and learning, there were several inputs given by students at the small-group stage, namely: 1) lack of legibility in filling in symbols and several other conditions in e-worksheets; 2) when inputting answers, the lack of shapes given; and 3) lack of legibility in providing instructions for filling.

The student worksheets can be implemented after going through the revision stages at the small-group stage. At the small-group stage, the revised results produced a prototype III, which could be given during field trials. The e-worksheets used and tried by students aim to determine whether these e-worksheets can improve students' MCT skills in the comparison of trigonometric function.

The process of implementing e-worksheets was carried out in six meetings. In the first meeting, the pretest was carried out. The learning process was carried out at the second meeting using the developed e-worksheets. Students experienced a little difficulty at this second meeting due to the novelty of the media provided during the learning process. At the third to fifth meetings, learning is carried out using the e-worksheets that have been developed. Students are used to learning using e-worksheet, so there are no problems when using e-worksheets. The following are some of the results of student answers when learning using e-worksheets.

In Figure 3, some student work results are shown on the e-worksheets on the e-worksheets page for the second to fifth meetings. The answers were obtained from the teacher's account that created the e-worksheets. All workmanship and student scores will be immediately captured for closed and open questions. The teacher can check first and then adjust the assessment of the results obtained by students. At the last meeting, namely the six meeting, students were given a post-test to measure the increase in critical thinking skills before being given a learning process using e-worksheets and after giving action on the second to fifth meetings using the e-worksheets that have been compiled.

The field test is the final stage, which aims to implement the results of the prototype III design and obtain results from student responses and post-tests. The results of student responses regarding the developed e-worksheets can be seen in Table 7.

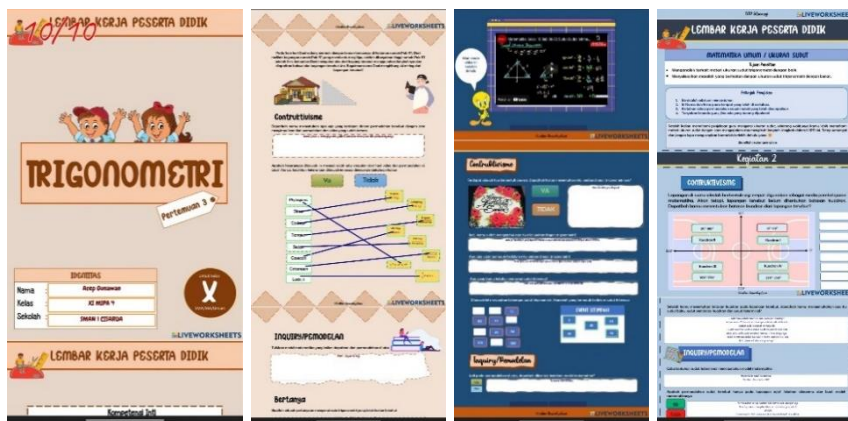


Figure 3. Result of students e-worksheets answer

Based on Table 7, it is revealed that in the material aspect, namely the problems contained in the e-worksheet can greatly help students in the comparison of trigonometric function so that it gets a percentage result of 90% in the very practical criteria. While in the language aspect, students easily understand the instructions for using the comparison of trigonometric function e-worksheets more than 87% in the very practical criteria. While in the media aspect, students can understand the comparison of trigonometric function through images or illustrations in e-worksheets by 90% in the very practical criteria. The average student response is 89%. It means the e-worksheet is very practical.

Table 7. Student response questionnaire results

No	Aspects assessed	Score	Percentage	Criteria
1	Material	3.6	90%	Very Practical
2	Language	3.5	87%	Very Practical
3	Media	3.6	90%	Very Practical
Average		3.56	89%	Very Practical

The pretest, post-test, and N-gain score is presented in Table 8. Based on Table 8. it can be concluded that all students's pretest scores are less than the minimum mastery criteria (72). On the other hand, based on the post-test, after learning, there were 66,7 % of students' mastery, which is in good criteria referred to in Table 3. The N-gain of students' critical thinking ability is 0,66, namely in moderate criteria.

Table 8. The student pretest score, post-test scores, MMC, and N-gain score

Students	Pretest	Minimum Mastery Criteria	Post-test	Minimum Mastery Criteria	N-Gain
S-1	53	Not Mastery	98	Mastery	0.96
S-2	56	Not Mastery	100	Mastery	1.00
S-3	54	Not Mastery	86	Mastery	0.70
S-4	53	Not Mastery	85	Mastery	0.68
S-5	50	Not Mastery	83	Mastery	0.66
S-6	55	Not Mastery	92	Mastery	0.82
S-7	49	Not Mastery	83	Mastery	0.67
S-8	48	Not Mastery	87	Mastery	0.75
S-9	55	Not Mastery	90	Mastery	0.78
S-10	46	Not Mastery	80	Mastery	0.63
S-11	46	Not Mastery	74	Mastery	0.52

Students	Pretest	Minimum Mastery Criteria	Post-test	Minimum Mastery Criteria	N-Gain
S-12	60	Not Mastery	100	Mastery	1.00
S-13	32	Not Mastery	70	Not Mastery	0.56
S-14	29	Not Mastery	60	Not Mastery	0.44
S-15	44	Not Mastery	73	Mastery	0.52
S-16	43	Not Mastery	89	Mastery	0.81
S-17	39	Not Mastery	71	Not Mastery	0.52
S-18	29	Not Mastery	70	Not Mastery	0.58
S-19	32	Not Mastery	71	Not Mastery	0.57
S-20	39	Not Mastery	70	Not Mastery	0.51
S-21	39	Not Mastery	68	Not Mastery	0.48
S-22	56	Not Mastery	82	Mastery	0.59
S-23	46	Not Mastery	70	Not Mastery	0.44
S-24	57	Not Mastery	86	Mastery	0.67
Average	46.25		80.75	Mastery with very good criteria	0.66

Figure 4 shows the success of students solving the critical mathematical thinking problems. The results of the students' answers show that there are two problems regarding comparison of trigonometric function. Both students can solve these problems systematically, as seen from the answers. Students can determine what comparison is used to prove the answers that are available. Then, students can determine the value of the special angle well to get the correct value.

(Translate)

The angular distance of a child is 32m, the elevation angles are 30° and 45° respectively. Proving the answer according to Andi and Sita

$$\tan = \frac{\text{side}}{\text{hypotenuse}} = \frac{32}{\text{hypotenuse}}$$

$$\tan 30 = \frac{32}{\text{hypotenuse}}$$

$$= \frac{32}{3} \sqrt{3}$$

$$\tan 45 = \frac{32}{\text{hypotenuse}}$$

$$\text{hypotenuse} = 32$$

So the tan value is $32 - \frac{32}{3} \sqrt{3}$. Andi's answer is correct

(Translate)

Given: hypotenuse 8, hypotenuse 30°

Question: datanya cukup? Buktikan panjang 8 m

Answer:

I think the answer is enough because it can be solved. I solved it by finding the sinus value first

$$\sin 30^\circ = \frac{1}{2} = \frac{\text{front}}{\text{hypotenuse}}$$

$$\text{hypotenuse} = 8 \times \frac{1}{2} = 4$$

Then the result is proven that the length is 8 m.

Figure 4. Result of students' answers

Figure 5 shows some of the students' errors in solving the students' critical mathematical thinking problems. The reason for students' errors in answering the critical mathematical thinking indicators is the lack of basic knowledge, shown by errors in arithmetic operations on fractions. Other errors occur when students determine the value of special angles; students do not know the value of trigonometric comparisons at special angles, so they write incorrect results. The last mistake commonly made by students is when understanding contextual problems; students are confused when modeling contextual problems into mathematical models, which can then be

solved using systematic solution steps. The factors commonly experienced by students will always be related to basic skills because when students' basic mathematical skills are good, it will make it easier to solve other problems (Hidayati, 2020).

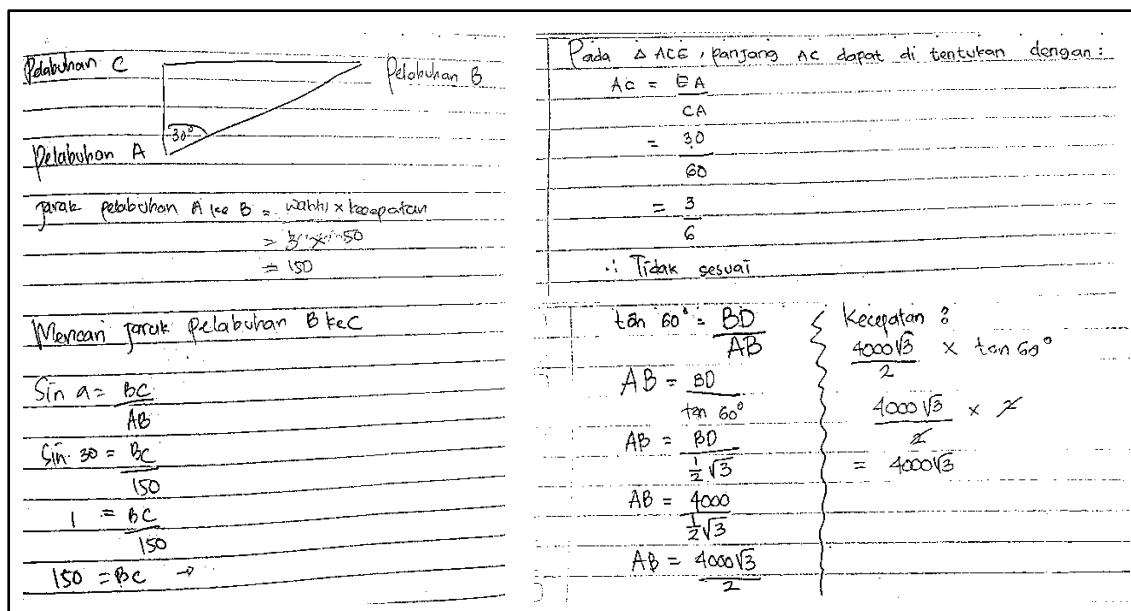


Figure 5. Example of incorrect answer

A valid, practical, and effective e-worksheets were obtained. The teaching materials are intended to change students' critical mathematical thinking skills. If seen from the results of one-to-one and small groups, students' critical mathematical thinking skills have changed. Students' ability to experience changes either increases or decreases based on the teaching materials provided by students during the learning process (Harjono, Gunawan, Adawiyah, & Herayanti, 2020). An appropriate approach must accompany the teaching material so students can easily accept it. With the success of the field tests that have been carried out, it can be said that teaching materials with this approach have succeeded in changing students' critical mathematical thinking skills (Saragih & Surya, 2017; Katyeudo & de Souza, 2022).

Another factor that can impact students' thinking skills, especially students' MCT, is the student environment (Minarni & Napitupulu, 2020). Students can improve their thinking skills by being assisted by a supportive environment to improve their abilities so they can easily accept the learning process and improve their critical thinking skills (Chukwuyenum, 2013). Students can change their MCT skills, as seen from the results obtained during the pretest and post-test, so these students already know the concept of solving a problem accompanied by problems that require MCT skills (Le & Phuong, 2017; Zhang, 2020).

Teaching materials must be developed to support the development of students' abilities, especially students' MCT skills (Afrilianto, Rosyana, Linda, & Wijaya, 2022; Suherman & Vidákovich, 2022). Teaching materials are very influential in improving students' MCT skills

because students will be helped to improve their MCT skills based on the assistance of teaching materials provided by the teacher during the learning process takes place (Fauzan, Andita, Rada, Zafirah, & bin Abdullah, 2022; Hidayat & Sari, 2019). Many teaching materials are used but are still less interactive, so the learning objectives are not achieved. So, worksheets are used in different forms and can be varied and interactive. The form of the worksheets is to use website assistance in the completion process. E-worksheets can motivate students because they have different ways of filling in and getting new experiences during the learning process. By learning to use e-worksheets, students can produce another ability, namely the affective ability of independent learning (Mulyasari, Gunarhadi, & Roemintoyo, 2022).

Developed e-worksheets make it easier for students to hone their cognitive and affective abilities. However, it can also help the teacher add material and check student answers. In using e-worksheets that the teacher has carried out, it is easy to add references for students to complete and provide understanding concepts through video forms, whether videos made by themselves or results from other platforms by simply adding video links. This can make it easier to develop student learning independence; in the video, you can add motivation to learning for students (Farman, Hali, & Rawal, 2021). So, the development of e-worksheets benefits students and teachers, who will benefit from the various features in the e-worksheets website.

It's just that there are a few obstacles in using the product, namely, the e-worksheet is a little difficult to apply in the form of a group; if in group form, e-worksheets must be accessed using a PC to make filling easier. In the automatic value assessment by the website, only on the closed problem section; for open problems, it must be corrected again, and the value is averaged. The website lacks symbols for solving mathematical problems, so it is necessary to collect manual solutions for open questions.

Conclusion

E-worksheet with web live worksheet using contextual teaching and learning approach on the comparison of trigonometric function produced can be used because it has met the valid, practical, and effective criteria, 1) valid criteria are met because based on the assessment of 2 expert validators and 1 practitioner validator the assessment is on valid criteria, so it only needs to be made some improvements; 2) practical criteria are met because the results of student responses to e-worksheet are 89% so that they are on very practical criteria; and 3) effective criteria are met because the effectiveness test results obtained a result of 80.75 which is in the Very Good category. In addition to obtaining the feasibility of the e-worksheet developed, an increase in students' MCT ability was also obtained, indicated by an N-gain value of 0.66 in the moderate category. The increase shows that e-worksheets using contextual teaching and learning

can improve students' MCT skills. The learning process is effective, so it positively impacts the development of e-worksheets and improves students' MCT skills. This means that the worksheets product developed can be used to improve students' MCT skills in the comparison of trigonometric function. Student errors in solving trigonometric comparison problems are caused by several factors, namely basic concepts, determining special angles, and understanding the problem.

References

- Afrilianto, M., Rosyana, T., Linda, L., & Wijaya, T. T. (2022). Project-activity-cooperative learning-exercise model in improving students' creative thinking ability in mathematics. *Infinity Journal*, 11(2), 285–296. <https://doi.org/10.22460/infinity.v11i2.p285-296>
- Agus, I. (2019). Efektivitas guided discovery menggunakan pendekatan kontekstual ditinjau dari kemampuan berpikir kritis, prestasi, dan self-efficacy. *Jurnal Riset Pendidikan Matematika*, 6(2), 120–132. <https://doi.org/10.21831/jrpm.v6i2.14517>
- Arikunto, & Suharsimi. (2011). *Research procedure a practice approach*. Earth Literacy.
- Chukwuyenum, A. N. (2013). Impact of critical thinking on performance in mathematics among senior secondary school students in Lagos State. *IOSR Journal of Research & Method in Education (IOSRJRME)*, 3(5), 18–25. <https://doi.org/10.9790/7388-0351825>
- Dvoryatkina, S. N., Melnikov, R. A., & Savvina, O. A. (2022). Reform and counter-reform of mathematics education in the USSR in 1960-1970. *Perspektivy Nauki i Obrazovania*, 60(6), 519–534. <https://doi.org/10.32744/pse.2022.6.31>
- Ernawati, T., & Sujatmika, S. (2021). Development of worksheet based on scientific approach to improve critical thinking skills. *International Journal of STEM Education for Sustainability*, 1(1), 1–10. <https://doi.org/10.53889/ijses.v1i1.1>
- Ernawati, Y. (2019). Pengembangan lembar kerja peserta didik (LKPD) pada materi teks fabel berbasis saintifik untuk siswa SMP kelas VIII. *Diksa: Pendidikan Bahasa dan Sastra Indonesia*, 5(2), 94–103. <https://doi.org/10.33369/diksa.v5i2.9982>
- Farman, F., Hali, F., & Rawal, M. (2021). Development of e-LKPD using live worksheets for online mathematics learning during covid-19. *JME (Journal of Mathematics Education)*, 6(1), 36-42. <https://doi.org/10.31327/jme.v6i1.1626>
- Fauzan, A., Andita, C. D., Rada, G., Zafirah, A., & bin Abdullah, A. H. (2022). Developing RME-based learning trajectory for teaching addition to a dyscalculia student in elementary school. *Jurnal Didaktik Matematika*, 9(1), 39–58. <https://doi.org/10.31327/jme.v6i1.1626>
- Harjono, A., Gunawan, G., Adawiyah, R., & Herayanti, L. (2020). An interactive e-book for physics to improve students' conceptual mastery. *International Journal of Emerging Technologies in Learning*, 15(5), 40–49. <https://doi.org/10.3991/IJET.V15I05.10967>
- Heidari, M., & Ebrahimi, P. (2016). Examining the relationship between critical-thinking skills and decision-making ability of emergency medicine students. *Indian Journal of Critical Care Medicine*, 20(10), 581–586. <https://doi.org/10.4103/0972-5229.192045>
- Hidayat, W., Rohaeti, E. E., Ginanjar, A., & Putri, R. I. I. (2022). An e-pub learning module and students' mathematical reasoning ability: A development study. *Journal on Mathematics Education*, 13(1), 103–118. <https://doi.org/10.22342/jme.v13i1.pp103-118>

- Hidayat, W., & Sari, V. T. A. (2019). Kemampuan berpikir kritis matematis dan adversity quotient siswa SMP. *Jurnal Elemen*, 5(2), 242–252. <https://doi.org/10.29408/jel.v5i2.1454>
- Hidayati, U. (2020). Analysis of student errors in solving trigonometry problems. *JME (Journal of Mathematics Education)*, 5(1), 54–60. <https://doi.org/10.31327/jme.v5i1.1181>
- Hobri, H., Arifin, S., Murtikusuma, R. P., Oktavianingtyas, E., & Putri, I. W. S. (2021). Students' critical thinking process in solving jumping task according to gregorc's thinking style. *Jurnal Didaktik Matematika*, 8(1), 15–31. <https://doi.org/10.24815/jdm.v8i1.19776>
- Jahic, H., & Pilav-Velic, A. (2020). STEM on demand – can current state of higher education infrastructure meet expectations? *Naše Gospodarstvo/Our Economy*, 66(3), 48–55. <https://doi.org/10.2478/ngoe-2020-0017>
- Katyeudo, K. K., & de Souza, R. A. C. (2022). Digital transformation towards education 4.0. *Informatics in Education*, 21(2), 283–309. <https://doi.org/10.15388/infedu.2022.13>
- Kristanti, F., Ainy, C., Shoffa, S., Khabibah, S., & Amin, S. M. (2018). Developing creative-problem-solving-based student worksheets for transformation geometry course. *International Journal on Teaching and Learning Mathematics*, 1(1), 13–23. <https://doi.org/10.18860/ijtlm.v1i1.5581>
- Le, T., & Phuong, H. (2017). Model for the Building of the Assessment Scale To Evaluate High School Students' Critical Thinking. *Journal Of Science Education Science*, 14(4), 189–200.
- Lestari, R., Prahmana, R. C. I., Chong, M. S. F., & Shahrill, M. (2023). Developing realistic mathematics education-based worksheets for improving students' critical thinking skills. *Infinity Journal*, 12(1), 69–84. <https://doi.org/10.22460/infinity.v12i1.p69-84>
- Madden, O., Sweeney, R., & Gonzales, A. (2023). Exploring the use of live interactive worksheets in foreign language classes: Perceptions of students and teachers. *International Journal of Language Instruction*, 2(4), 143–154.
- Mahmuzah, R., Ikhsan, M., & Yusrizal, Y. (2014). Peningkatan kemampuan berpikir kritis dan disposisi matematis siswa smp dengan menggunakan pendekatan problem posing. *Jurnal Didaktik Matematika*, 1(2), 43–53.
- Minarni, A., & Napitupulu, E. E. (2020). the role of constructivism-based learning in improving mathematical high order thinking skills of Indonesian students. *Infinity Journal*, 9(1), 111–132. <https://doi.org/10.22460/infinity.v9i1.p111-132>
- Mulenga, E. M., & Marbán, J. M. (2020). Prospective teachers' online learning mathematics activities in the age of COVID-19: A cluster analysis approach. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(9), 1–9. <https://doi.org/10.29333/EJMSTE/8345>
- Mulyasari, D. W., Gunarhadi, & Roemintoyo. (2022). E-LKPD based on problem based learning (PBL) approach to measure mathematics literacy ability of elementary students. *International Journal of Elementary Education*, 6(3), 393–402. <https://doi.org/10.23887/ijee.v6i3.47532>
- Nugraheny (2018). Penerapan lembar kerja peserta didik (LKPD) berbasis life skills untuk meningkatkan keterampilan proses dan sikap ilmiah. *Visipena Journal*, 9(1), 94–114. <https://doi.org/10.46244/visipena.v9i1.435>
- Nurhidayah, D., & Pratama, A. T. (2024). Students' e-worksheet based on project and character of Pancasila through environmental issues: What are the characteristics?. *RADEN: Research and Development in Education*, 4(1), 113–126. <https://doi.org/https://doi.org/10.22219/raden.v4i1.32159>

- Ojmiba, D. P., Gogo, Z. I., & Cletus, S. A. (2021). Comparative assessment of student and teacher perception of the curriculum content difficulty in Further Mathematics. *International Journal of Research and Innovation in Social Science*, 5(3), 384–391.
- Rukman, N. K., Zulfikar, R. N., & Rahayu, A. P. (2023). Development of lift the flap book as memet (mathematics learning media) trigonometry materials for high school students. *Cendikia: Media Jurnal Ilmiah Pendidikan*, 13(3), 489–500.
- Saragih, D. I., & Surya, E. (2017). Analysis of the effectiveness of mathematics learning using contextual learning model. *International Journal of Sciences: Basic and Applied Research*, 34(1), 135–143. <http://gssrr.org/index.php?journal=JournalOfBasicAndApplied>
- Sibaen, N. W., Buasen, J. A., & Alimondo, M. S. (2023). Principal components of students' difficulties in mathematics in the purview of flexible learning. *Journal on Mathematics Education*, 14(2), 353–374. <https://doi.org/10.22342/jme.v14i2.pp353-374>
- Sugandi, A. I., & Maya, R. (2020). Pelatihan menanamkan konsep bilangan pecahan untuk guru-guru SD dengan menggunakan visual basic application ((VBA)) for microsoft excel di Kecamatan Pangalengan Kabupaten Bandung. *Abdimas Siliwangi*, 03(01), 60–73.
- Suherman, S., & Vidákovich, T. (2022). Assessment of mathematical creative thinking: A systematic review. *Thinking Skills and Creativity*, 44, 1–13. <https://doi.org/10.1016/j.tsc.2022.101019>
- Tessmer, M. (1993). *Planning and conducting formative evaluations*. Routledge: Abingdon.
- Tohir, M. (2019). Hasil PISA Indonesia tahun 2018 turun dibanding tahun 2015. *Preprints*, 4(3), 1–10. <https://doi.org/10.17605/OSF.IO/8Q9VY>
- Wahyuni, S., Erman, E., Sudikan, S., & Jatmiko, B. (2020). Edmodo-based interactive teaching materials as an alternative media for science learning to improve critical thinking skills of junior high school students. *International Journal of Interactive Mobile Technologies*, 14(9), 166–181. <https://doi.org/10.3991/ijim.v14i09.13041>
- Yang, D. C., & Sianturi, I. A. (2017). An analysis of Singaporean versus Indonesian textbooks based on trigonometry content. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(7), 3829–3848. <https://doi.org/10.12973/eurasia.2017.00760a>
- Yaumi, M. (2018). *Media dan teknologi pembelajaran*. Gramedia Grup.
- Yunianta, T. N. H., Herman, T., Wizhar, A. B., & Kurniawan, M. A. F. (2023). Development of mathematics e-module using kodular and flipbook for junior high school students: Differences. *Jurnal Didaktik Matematika*, 10(1), 1–16. <https://doi.org/10.24815/jdm.v10i1.29730>
- Zamzam, G. L., Komarayanti, S., & Mahfud, M. Z. (2023). The Effect of Using Liveworksheets Learning Media on Student Interests and Learning Outcomes in Ecosystem Material. *International Social Sciences and Humanities*, 2(2), 491–494. <https://doi.org/10.32528/iss.v2i2.249>
- Zhang, Y. (2020). Developing EFL students' critical thinking competence in English reading class. *Creative Education*, 11(07), 1145–1151. <https://doi.org/10.4236/ce.2020.117085>
- Zulmi, F. A., & Akhlis, I. (2020). Pengembangan LKPD berekstensi EPUB berbasis discovery learning untuk mengembangkan keterampilan berpikir kritis peserta didik. *UPEJ Unnes Physics Education Journal*, 9(2), 209–216. <https://doi.org/10.15294/upej.v9i2.41373>