

## Computational Thinking (CT)-based Student Worksheet to Improve the Mathematical Literacy of Mathematics Prospective Teacher

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### ABSTRACT

Mathematical Literacy ability has important for prospective mathematics teachers. It is closely related to Computational Thinking (CT). The aim of this study is to produce CT-students worksheets to improve the mathematical literacy of prospective mathematics teachers. The development study using model ADDIE (Analysis, Design, Development, Implementation, and Evaluation). Thirty-seven would-be maths teachers participated in the study's sixth semester. Subject criteria are students who are not familiar with CT. The instruments in this study were CT-based student worksheets, validation sheets, student response questionnaires, pre-test and post-test questions. The results showed that CT-based student worksheets met the criteria of valid (validity percentage of 84.5%), practical (practicality percentage of 88.68%), and effective (N-gain value of 46.91%). Based on these results, it's appropriate to conclude that CT-based student papers can help students who want to become math teachers learn more about math. Recommendations for further research can be made on the development of a wider material and a wider subject as well.

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## 1. INTRODUCTION

The Organisation for Economic Cooperation and Development (OECD) administers the Programme for International Student Assessment (PISA) test, which aims to assess students' mathematical competency on a global scale. In the year 2018, Indonesia's ranking among the 79 member nations of the Programme for International Student Assessment (PISA) was 69th. The average score obtained by Indonesian students in the domain of numerical proficiency was 379, which is lower than the average score of 487 seen among member nations of the Organisation for Economic Co-operation and Development (OECD) (Kemdikbud, 2019; Nur'aini et al., 2021). In the meantime, The Trend in International Mathematics and Science Study (TIMSS) showed that Indonesia is positioned 64 out of 72 nations overviewed (Fenanlampir et al., 2019). In this way, in light of these reviews, the numerical education abilities of Indonesian understudies have not had the option to contend with different nations on the planet (Afriyanti et al., 2018).

According to Megawanti et al. (2022), teachers' failure to integrate mathematics instruction with student culture is the primary cause of this low level of mathematical literacy. According to Arisetyawan & Supriadi (2020), the teacher only communicates what is written in the book without encouraging students to think critically. According to Anggraini et al. (2019), the mathematics that is taught in schools lacks context and is far from the reality of everyday life. According to Mania & Alam (2021), one of the reasons students don't use mathematics to solve problems they face every day is that teachers don't connect math to the culture of the classroom. According to Jamil & Khusna (2020), SW is one of the teaching resources that can be utilized when learning mathematics. According to Choo et al. (2011), SW gives students instructions or an overview of the steps they need to take to solve problems. A good SW can help teachers learn and assist students in solving problems on their own (Basuki & Wijaya, 2018; Sipayung & Simanjuntak, 2018; Vitoria & Monawati, 2020). For this situation, the improvement of SW to foster understudies' numerical education should be finished. SW to be grown should be coordinated into the setting of the climate as a component of understudy life.

Since the utilization of setting in learning arithmetic is viewed as vital (Effendi et al., 2019; Maharani & Suprpto, 2018). This is because students are able to discover meaningful connections between abstract and concrete concepts in real-world contexts thanks to learning in context. Through discovery, reinforcement, and connection, the idea is internalized in the meantime. The local context is one type of context that can be used. Students are better able to relate math problems to their own lives when local contexts are used (Charmila et al., 2016). Utilizing content and setting that connects with understudies' everyday exercises makes learning simpler (Batlolona et al., 2019). Students can solve the problem by changing the complex problem to a simpler problem.

Computational Thinking (CT) is a process that can be used to solve a complex problem. CT was initially only used in computer science, but as the era progresses, CT can be integrated into other sciences other than computer science. Wing (2006) explains that CT is a form of reformulating a seemingly difficult problem into a problem that we know how to solve, perhaps by reduction, embedding, transformation, or simulation. Yadav et al. (2014) define CT as a mental activity to abstract problems and formulate solutions that can be automated, whereas Jenson & Droumeva (2016) defines it as the thought process involved in formulating a problem and its solution so that the solution is represented in a form that can be performed effectively by an information processing agent. According to Werner et al. (2014), Algorithmic thinking involves defining a problem, breaking it into smaller parts, and identifying steps to solve the problem. So it can be concluded that CT is a person's thinking process in solving complex problems using the most effective strategies that are formulated by themselves.

CT is generalizable to other disciplines, a general problem-solving approach applicable to a wide variety of STEM and non-STEM fields. The formal definition is still a topic of open discussion in the literature (Barr & Stephenson, 2011; Grover & Pea, 2013), but overall, scholars agree that computational thinking skills include algorithmic thinking, navigating multiple levels of abstraction, breaking down problems into manageable parts, and representing data through models. Computational thinking can be taught with or without the use of a computer (Bell et al., 2012). In addition, CT and scientific literacy are competencies that must be possessed by prospective elementary school teachers in the 21st century (Fakhriyah et al., 2019).

In its development, there are three CT and literacy frameworks. First, CT is a new literacy. CT becomes literacy itself. Second, CT through literacy. The meaning of this sentence is that CT can be improved or developed through literacy. While the third framework is literacy through CT, which means that one's literacy can be increased through CT. CT and algorithmic logic should be considered as core literacy that needs to be included in the school curriculum alongside numeracy, textual literacy, and scientific thinking (DiSessa, 2018; Wing, 2011). CT can also be paired with other competency-based technology literacy, which includes technology prototyping, encouraging applied creativity, as well as design thinking (Jenson & Droumeva, 2016). Students can practice CT skills if they have proper scientific literacy. CT is a new form of literacy, meaning that integrating CT into literacy practice will affect students' literacy skills to improve computational results and develop student literacy through computational practice (Jacob & Warschauer, 2018). Therefore, to bridge the development of science with all the provisions of curriculum content and student needs, teaching materials that contain appropriate scientific literacy are needed.

So far, it is rare to find teaching materials in the learning process on campus. Students only learn from the material presented by the lecturer. They tend to do less practice questions. Based on the results of observations, the existing teaching materials do not contain CT elements at all. Even just in the form of teaching modules that are thick and minimal about practice. Even though students' thinking levels are already high, there are times when inserting or integrating CT into learning with examples in daily activities is also necessary. Because CT is actually not only done in solving math problems, but also implemented in the real world.

Given these problems, it is necessary to develop a teaching material which includes the integration of CT in everyday life. Teaching materials that can be developed are LKM for students as training materials in understanding the material being taught. One of the subjects that require high thinking is calculus. In this study, a teaching material was developed in the form of CT-based LKM in everyday life in calculus courses. Fakhriyah et al. (2019) state that science conceptual learning materials affect students' CT skills with scientific literacy better than learning using lecturer handouts. These learning materials can be implemented in learning to develop CT skills.

Previous studies that underline this research are research conducted by Amir et al. (2023), who developed student worksheets to improve mathematical literacy using local wisdom as a tool in transferring knowledge. The results of the study show that student worksheets can improve students' mathematical literacy. According to a study by Triyana & Mahmudah (2020), statistical material produces student worksheet on mathematical literacy, assisting students in the growth and development of their mathematical literacy skills. Concentrate by Khaesarani & Ananda (2022) forms student worksheet numerical education in factual material that can further develop understudy learning results. In addition, research conducted by Maharani et al. (2020) developed CT-based worksheets for PAUD students. The results show that the development provides great benefits for classroom learning, enabling students to learn more effectively. The consequences of writing studies and field studies from Kurniasi et al. (2022) show that it is important to create showing materials as request-based electronic modules to further develop computational reasoning abilities in secondary school arrangements and series material.

Research from Putri et al. (2023) shows that Advanced Base learning projects are powerful on understudies' computational capacities in taking care of central school numerical statements. According to previous research by Samala et al. (2019), students will gain valuable experience that will help them deal with debates and everyday events in society in the future if they learn computational thinking and mathematical thinking skills that are tailored to their cognitive style. The significance of this is that learning science is not just procedural capacity, it is more vital to decipher and fabricate understudies' mental. In addition, other studies indicate that providing instruments or questions with CT indicators can also stimulate computational thinking in addition to learning. According to research Kawuri et al. (2019), critical thinking and problem-solving abilities can be developed through the use of computational thinking tests.

Based on these things, this research is important to do considering the need for CT capabilities in the 21st century. If students are left alone without being trained in CT, it will have a negative impact on the development of science. In addition, the lack of mathematical literacy will make the next generation of the nation not mathematically literate. So that in instilling mathematical concepts will be hampered. So it is necessary to find a solution of how to integrate CT in learning to increase the mathematical literacy of

prospective mathematics teachers.

## 2. METHODS

The type of research used is research with development methods or often called RnD (*Research and Development*). This development research uses the ADDIE development model. The ADDIE development model has five stages, namely analysis, development, design, implementation, and evaluation.

### a. Analysis

In the early stages of the research, the researcher conducted an analysis in the form of needs analysis, learning materials, environment and problem identification through interviews conducted with mathematics teachers. Interviews conducted by researchers with lecturers discussed the obstacles in learning calculus in the era of technology and media use.

### b. Design

At this stage, the researcher designs electronic-based learning media products, namely student worksheets in calculus courses, by first identifying needs analysis. This stage includes product design planning, namely the student worksheet framework, learning objectives, materials, instructions for use, and evaluation. At the time of design, the researcher also prepared the materials used in making student worksheets according to the learning objectives. At this stage, the researcher consulted with experts.

### c. Development

Researchers develop products from previously designed student worksheets. Researchers make student worksheets based on the concepts and designs that have been designed. The output of the student worksheet developed is in the form of hardcopy in the form of a book that students can use in learning calculus. Before being implemented, the product will be validated by experts, namely material experts, media design experts, and practitioner experts. With validation by experts, it is hoped that the media that have been made can be accounted for, including validation of student worksheet teaching materials, validation of student response questionnaires, validation of pre-test and post-test question sheets.

### d. Implementation

At this stage, the researcher implements or applies the media that has been developed for prospective mathematics teacher students. Product application is used to determine the feasibility and legibility of student worksheets that have been developed through limited trials and field tests.

### e. Evaluation

After carrying out the implementation, this evaluation stage is the stage for analyzing the validity, practicality, and effectiveness of CT-based student worksheets to increase the mathematical literacy of prospective mathematics teacher students in the form of conclusions obtained from the validation assessment of research instruments and product test results (pre-test and post-test).

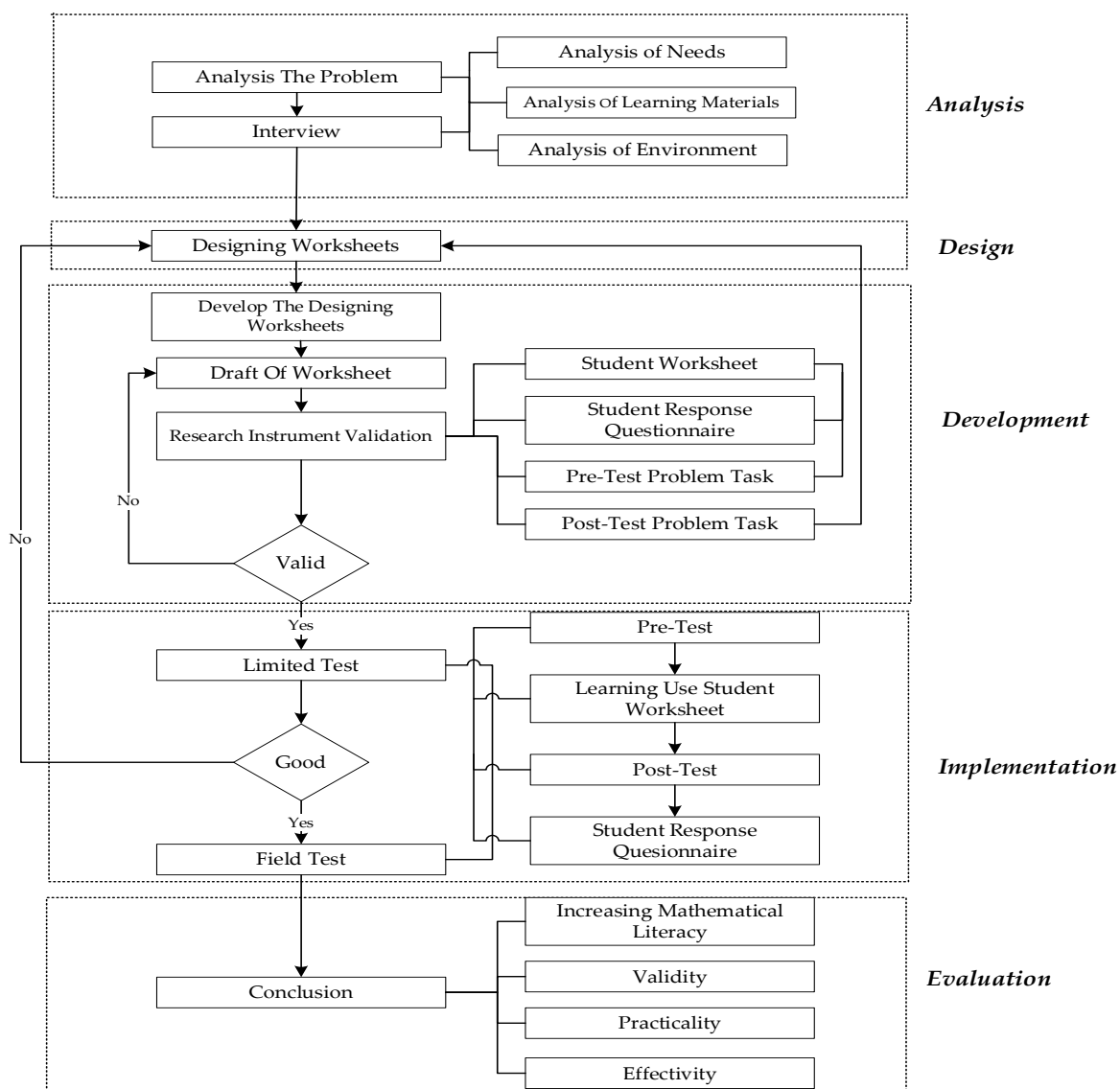


Figure 1. Research Procedure

### 3. FINDINGS AND DISCUSSION

#### 3.1 Result

Based on the research and development of CT-based student worksheet teaching materials that have been implemented, the following results are obtained:

#### a. Analysis

##### 1. Analysis of Needs

The learning tools used in learning calculus in the Department of Mathematics Education at the Universitas PGRI Madiun are still conventional. Learning media sometimes only use PPT or videos from YouTube and not much material uses student worksheets in learning.

##### 2. Analysis of Learning Materials

Based on the observations of researchers at the Department of Mathematics Education, Universitas Madiun and unstructured interviews with calculus lecturers, it was found that the mathematical literacy of prospective mathematics teachers is still low, so there is a need for teaching materials for students to support their understanding of mathematical concepts and increase their mathematical literacy. Material that can be improvised is logarithmic material.

#### b. Design

##### 1. Instrument Design

##### a) Validation Sheet of student worksheet

The CT-based student worksheet validation sheet on the logarithmic material that has been

compiled is 12 statement items on the student worksheet validation sheet. The statements on the validation sheet contain aspects of content feasibility, language feasibility aspects, activity feasibility aspects as well as implementation and measurement feasibility aspects with assessment, 5: very good, 4: good, 3: good enough, 2: not good and 1: very not Good. At the end of the sheet the validator can provide suggestions for the device being developed.

b) Student Response Questionnaire Sheet

The response questionnaire sheet contains 15 statement items which are used to view and assess several aspects, namely interest, material, and language, when students work on student worksheets. The statements consist of 8 positive statements and 7 negative statements. Students can check the column strongly agree, agree, disagree or disagree. The scale used is the Likert scale.

c) Validation Sheet of Student Response Questionnaire Sheet

The student response questionnaire validation sheet that has been compiled is 9 statement items. The statements on the validation sheet contain aspects of instructions, content aspects and language aspects with an assessment, 5: very good, 4: good, 3: quite good, 2: not good and 1: very bad. At the end of the sheet, the validator can provide suggestions for the device being developed.

d) *Pre-Test* Questions Sheet

The *Pre-Test* question sheet consists of 3 essay questions which cover logarithm material. The questions have a score of 10 for each item and have an overview of the fulfillment of mathematical literacy indicators.

e) Validation Sheet of *Pre-Test* Questions

The *Pre-Test* validation sheet that has been prepared is 10 statement items. The statements on the validation sheet contain an assessment, 5: very good, 4: good, 3: good enough, 2: not good and 1: very bad. At the end of the sheet the validator can provide suggestions for the device being developed.

f) *Post-Test* Questions Sheet

The *Post-Test* question sheet consists of 3 essay questions which cover logarithm material. The questions have a score of 10 for each item and have an overview of the fulfillment of mathematical literacy indicators.

g) Validation Sheet of *Post-Test* Questions

The *Post-Test* validation sheet that has been prepared is 10 statement items. The statements on the validation sheet contain an assessment, 5: very good, 4: good, 3: good enough, 2: not good and 1: very bad. At the end of the sheet the validator can provide suggestions for the device being developed.

2. Initial Design

The initial design of CT-based student worksheet teaching materials in the form of hardcopy with front cover contents, learning outcomes, learning objectives, instructions for use and questions regarding calculus. The questions presented certainly have an overview of the fulfillment of mathematical literacy indicators. CT in the student worksheet is integrated into questions with examples of structured answers. Starting from decomposition, abstraction, pattern recognition, algorithms presented in the example questions and answers. The design of the CT-based student worksheet can be viewed in Figure 1 below.

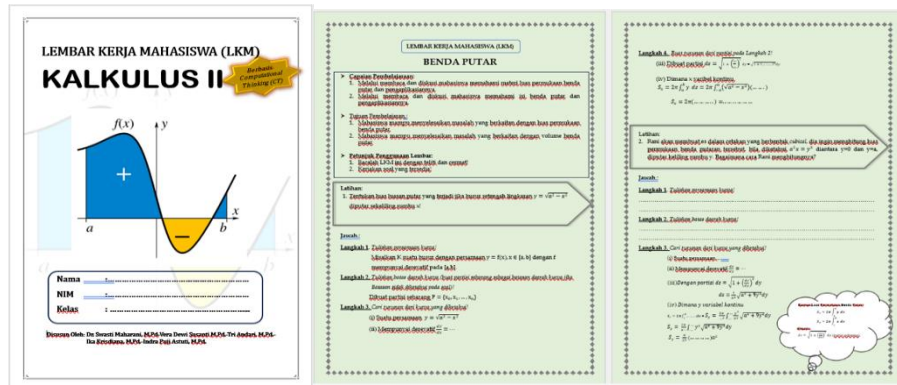


Figure 2. The Design of CT-based Student Worksheet

c. Development

1. Student worksheet development results

The developed student worksheet is a new student worksheet that has never existed before. Student worksheets in the form of hardcopy printed on B5 size paper. Inside the student worksheet there are learning materials and examples of problems in everyday life that are arranged in such a way as to lead to the four foundations of CT, namely decomposition, abstraction, pattern recognition, and algorithmic.

2. Validation of Teaching Materials and Research Instruments

Learning device validation aims to see whether CT-based student worksheets are really valid so that the research carried out has validity. If the validation results show that the results are not yet valid, then it is mandatory to carry out product revisions in accordance with the suggestions given by the validator and re-validate the instruments that have been revised or corrected. The results of the validation of the instrument sheet and the design of the CT-based student worksheet teaching materials that were validated can be seen as follows.

a) Validation of student worksheet

Validation of student worksheets is made to determine the accuracy of student worksheets as teaching materials for learning by integrating CT in Calculus subject on Logarithms.

Table 1. Validity of student worksheet

Validation Result	Validators	
	I	II
Total Score obtained	54	48
Maximum Total Score	60	60
Percentage of Validation	89%	80%
Combined Percentage	84.5%	

Based on the table above, it shows that the validation results of CT-based student worksheets have a validity of 84.5%.

b) Validation of Student Response Questionnaire

Validation of the student response questionnaire sheet was made to determine the accuracy of the response questionnaire for prospective mathematics teachers.

Table 2. Validity of student response questionnaire

Validation Result	Validators	
	I	II
Total Score obtained	39	40
Maximum Total Score	45	45
Percentage of Validation	88.67%	88.89%
Combined Percentage	88.78%	

Based on the table above, it shows that the validation results of the student response

questionnaire sheet have a validity of 87.78%.

c) Validation of Pre-Test Questions

The validation of the pre-test questions was made to determine the accuracy of the questions to be worked on by prospective mathematics teacher students.

**Table 3.** Validity of pre-test questions

Validation Result	Validators	
	I	II
Total Score obtained	41	43
Maximum Total Score	50	50
Percentage of Validation	84%	86%
Combined Percentage	85%	

Based on the table above, it shows that the results of the pre-test questions have a validity of 85%.

d) Validation of Post-Test Questions

Post-test item validation was made to determine the accuracy of the questions to be worked on by prospective mathematics teacher students.

**Table 4.** Validity of post-test questions

Validation Result	Validators	
	I	II
Total Score obtained	43	44
Maximum Total Score	50	50
Percentage of Validation	86%	88%
Combined Percentage	87%	

Based on the table above, it shows that the results of the post-test questions have a validity of 87%.

d. Implementation

1. Limited Test

A limited test in this study involved 8 students from class 6B with the selection of students made on the recommendation of a calculus lecturer. Implementation begins with the provision of pre-test questions after which the researcher presents the achievements and learning objectives in logarithmic material. Students are divided into two heterogeneous groups (male and female). Each group discusses the material and works on student worksheets. Students are appointed to present the results of their group discussions. After the work and presentation of the student worksheet have been completed, it is continued with the work on the post-test question sheet and filling out the student response questionnaire.

a) Practicality Results in the Limited Test

The practicality of student worksheets in limited trials was obtained based on the results of the questionnaire responses of students who had attended limited trials. The results of the practicality analysis of learning devices can be seen in the following table.

**Table 5.** Practicality of limited test

Practicality of CT-based student worksheets	
Combined T-Sep	410
Combined S-Max	480
Combined percentage	87.45%
Category: Very Practical	

Based on the table above, it shows that the developed student worksheet gets a percentage of 87.45%. According to Kumalasani (2018) explain that percentage 87.45% are included in the very practical category or can be used without revision. So, it can be concluded that the student response in the limited trial of CT-based student worksheets was positive. This means that the learning tools developed meet practical criteria and can be field tested.

b) Limited Test Effectiveness Results

The effectiveness of the student worksheet can be determined by the N-Gain score of the pre-test scores obtained from the learning achievement test before carrying out learning activities using the LKM with the post-test scores coming from the learning achievement test after carrying out learning activities using student worksheets. N-Gain analysis can be calculated using Microsoft Excel. The results of the analysis of the effectiveness of student worksheets can be seen in the following table.

Table 6. The effectiveness of limited test

<b>The effectiveness of CT-based student worksheets</b>	
Total Pre-Test Score	278
Total Post-Test Score	530
Average Percentage N-Gain	48.28%
Category: Medium	

Based on the analysis in the table above, it shows that the developed student worksheet has an average percentage of effectiveness in limited trials of 48.28%. According to Pratiwi et al (2020) explained that the percentage of 48.28% was effective in the moderate category. These results already meet the achievement indicators of learning tools, namely the effectiveness of more than 30%.

## 2. Field Test

The field test in this study involved 18 students from class 6A. Implementation begins with the provision of pre-test questions, after which the researcher presents the achievements and learning objectives in logarithmic material. Students were divided into six groups heterogeneously (male and female), each group discussed the material and worked on student worksheets. Students are appointed to present the results of their group discussions. After the work and presentation of the student worksheet have been completed, it is continued with the work on the post-test question sheet and filling out the student response questionnaire.

### a) Practical Results in Field Tests

The practicality of the student worksheet in the field test was obtained based on the results of the student response questionnaire that had taken the field test. The results of the practicality analysis of learning devices can be seen in the following table.

Table 7. The practicality of field test

<b>Practicality of CT-based student worksheet</b>	
Combined T-Sep	1251
Combined S-Max	1440
Combined of percentage	88.68%
Category: Very Practical	

Based on the table above, it shows that the developed student worksheet gets a percentage of 86.88%. Kumalasan (2018) explained that the percentage of 86.88% was included in the very practical category or could be used without revision. So, it can be concluded that the student response in the field test to the student worksheet is positive. This means that the learning tools developed meet practical criteria.

### b) Field Test Effectiveness Results

The effectiveness of student worksheets can be determined by the N-Gain score of the pre-test values obtained from the learning achievement test before carrying out learning activities using student worksheets, with post-test scores originating from the learning achievement test after carrying out learning activities using student worksheets. N-Gain analysis can be calculated using Microsoft Excel. The results of the analysis of the effectiveness of student worksheets can be seen in the following table.

Table 8. The effectiveness of field test

<b>The Effectiveness of CT-based student worksheet</b>	
Total Pre-Test Score	778
Total Post-Test Score	1538.9
Average Percentage N-Gain	46.91%
Category: Medium	

Based on the analysis in the table above, it shows that the developed student worksheets

have an average percentage of effectiveness in limited trials of 46.91%. According to Pratiwi et al. (2020) explained that the percentage of 46.91% was effective in the moderate category. These results already meet the achievement indicators of learning tools, namely the effectiveness of more than 30%.

e. Evaluation

1. Analysis of the validity of CT-based student worksheets

Student worksheets teaching material instruments, student response questionnaires, pre-test questions and post-test questions can be declared valid if the combined validation of each validator meets the validity criteria with a percentage exceeding 70.01%. Student worksheets get a validity percentage of 84.5%. Student response questionnaires obtained a validity percentage of 88.78%. The pre-test questions obtained a validity percentage of 85% and the post-test questions obtained a validity percentage of 87%. From the results of the validity, Sistryarini & Nurtjahyani (2017) explained that the percentage of validity obtained by each student worksheet, student response questionnaire, pre-test questions and post-test questions had quite valid criteria.

2. Analysis of the practicality of CT-based student worksheets

The practicality of student worksheets is obtained by filling out a questionnaire on the responses of prospective mathematics teacher students to the learning tools developed. In research that has been carried out, the percentage of filling out student response questionnaires in limited trials was 87.45%. Meanwhile, the field test obtained a percentage of 88.68%. The percentage results on the practicality of the learning tools developed from each of these trials have reached  $\geq 75.01\%$  so that it can be said that the CT-based student worksheets developed meet practical criteria.

3. Analysis of the effectiveness of CT-based student worksheets

The effectiveness of student worksheets is obtained by calculating the N-Gain on the results of working on the pre-test and the results of working on the worksheets as a post-test. In research that has been carried out the percentage of N-Gain in limited trials is 48.28%. Meanwhile, in the field test, a percentage of 46.91% was obtained. The percentage results on the effectiveness of learning tools developed from each of these trials have reached  $\geq 30\%$ . So that student worksheets can be declared effective in learning.

### 3.2 Discussion

The results showed that the developed CT-based student worksheet met the valid, practical, and effective criteria. This is because CT-based student worksheets have never existed before and in these student worksheets, there are structured problem exercises that are arranged based on the four CT foundations which can improve students' mathematical literacy skills. CT-based student worksheets make it easier for students to understand Calculus II material. CT-based student worksheets have benefits as one of the teaching materials in implementing classroom learning.

The developed student worksheets are very practical to use because they are easy to access, easy to carry, and easy to learn. The contents of the student worksheets also direct students to think about CT in a complete and directed manner. Hardcopy student worksheets are easier to use in learning (Effendi et al., 2019; Krisdiana et al., 2019; Susanti, 2017). Learning that integrates CT in it can train students to always think about CT in their daily lives. This will have a great impact on students' thinking in life after graduation (Angeli et al., 2016; Maharani et al., 2020; Sung et al., 2017).

The application of CT in student worksheets teaching materials is something new for students who are prospective math teachers who have never known CT before. The use of CT as a learning approach can provide learning that is not only centred on the teacher, but students can play an active role in the learning itself (Kotsopoulos et al., 2017; Yadav & Berges, 2019). So that it is in accordance with 21st-century learning, which requires schools to apply a student-centered

learning approach. This shows that the learning tools developed are very suitable for increasing the mathematical literacy of prospective mathematics teacher students.

#### 4. CONCLUSION

The results of research on the development of CT-based student worksheets to improve student mathematical literacy have yielded results that student worksheet teaching materials are feasible to use and apply and can assist the learning activities to improve student mathematical literacy. The results obtained in detail are as follows, namely in research that has carried out student worksheets to obtain a validity percentage of 84.5%. Student response questionnaires obtained a validity percentage of 88.78%. The pre-test question sheet obtained a validity percentage of 85% and the post-test question sheet obtained a validity percentage of 87%. The practicality of student worksheets is included in the very practical category in terms of the results of the student response questionnaire, which showed 87.45% in the limited trial and 88.68% in the field test.

Student worksheet teaching materials are effective in the medium category based on N-Gain calculations on the results of pre-test and post-test question sheets. In research that has been carried out the percentage of N-Gain in limited trials is 48.28%. Meanwhile, in the field test, a percentage of 46.91% was obtained. So it can be stated that student worksheets can increase student mathematical literacy. The weakness of this development lies in the student worksheet version. The form is still in the print version, not yet up to the online version. The online version can also be made in pdf format but this is considered less interactive. It is hoped that in the future it will be possible to develop CT-based student worksheets in an interactive online version and in broader learning materials.

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