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Development of Rational Function Integral E-Worksheet with Linear Factor Denominators to Improve Mathematical Creative Thinking Ability

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ABSTRAK

Belum adanya Lembar Kerja elektronik yang dapat membantu mahasiswa dalam mengoptimalkan kemampuan berpikir kreatif matematis pada materi Teknik Integrasi Integral Fungsi Rasional dengan Penyebut Merupakan Faktor Linear menjadi latar belakang dilakukannya penelitian ini. Tujuan penelitian ini yaitu untk menghasilkan e-worksheet yang bisa digunakan pada mata kuliah kalkulus integral khususnya materi Teknik Integrasi Integral Fungsi Rasional dengan Penyebut Merupakan Faktor Linear dan dapat meningkatkan kemampuan berpikir kreatif matematis. Penelitian dilakukan dengan menggunakan model pengembangan ADDIE. Subjek penelitian adalah 15 orang mahasiswa Pendidikan Matematika Universitas Riau. Instrumen pengumpulan data menggunakan angket dan tes dengan analisis deskriptif kuantitatif dan kualitatif. Dari perhitungan skor validasi, secara keseluruhan e-worksheet sudah valid dan dapat digunakan mahsiswa Pendidikan Matematika di mata kuliah Kalkulus Integral. Berdasarkan hasil angket respon mahasiswa kedua e-worksheet telah memenuhi kriteria kepraktisan dengan pencapaian e-worksheet 1 sebesar 83.33% dan e-worksheet 2 sebesar 76.3%. Dari hasil uji efektivitas worksheet, telah terjadi peningkatan kemampuan berpikir kreatif matematis mahasiswa setelah menggunakan e-worksheet dari 2.73 menjadi 7.6 dan berada pada kategori medium. Merujuk pada hasil penelitian ini, berarti e-worksheet yang dikembangkan layak digunakan dan dapat meningkatkan kemampuan berpikir kreatif matematis mahasiswa.

ABSTRACT

There is no electronic worksheet that can help students to optimize their mathematical creative thinking skills in the Integral Integration technique of rational functions with the denominator is a linear factor being the background for this research. This research aims to produce an e-worksheet that can be used in integral calculus courses, especially material for Integral Integration techniques of rational functions with the denominators being linear factors, and can improve the ability to think creatively mathematically. The research was conducted using the ADDIE development model. The research subjects were 15 students of Mathematics Education at the University of Riau. Data collection instruments used questionnaires and tests with quantitative and qualitative descriptive analysis. From the calculation of the validation score, overall, the e-worksheet is valid and can be used by Mathematics Education students in Integral Calculus courses. Based on the results of the second student response questionnaire, the e-worksheet met the practical criteria with the achievement of e-worksheet 1 of 83.33% and e-worksheet 2 of 76.3%. From the results of the worksheet effectiveness test, there has been an increase in students' mathematical creative thinking ability after using e-worksheet from 2.73 to 7.6 and is in the medium category. Referring to the results of this study means that the developed e-worksheet is feasible to use and can improve students' mathematical creative thinking abilities.

1. INTRODUCTION

Education plays an essential role in the success of industry 5.0 to create quality Human Resources and support collaboration between humans and machines when working (Carayannis & Morawska-Jancelewicz, 2022; Skobelev & Borovik, 2017). Therefore, students need to be equipped with the competencies required at this time, namely adaptive, communicative, reactive, digital literacy, understanding, critical thinking, fighting spirit, and creative thinking. Thinking creatively is one of the abilities needed to face the challenges of today's times. Mathematics material is one of the materials that allow students to train competencies such as the ability to think creatively mathematically and the attitudes needed at this time (Kamarullah, 2017; Siregar, 2019). Various mathematical materials can train the ability to think creatively mathematically, one of which is the Rational Function Integration Technique material in the Integral Calculus course. This is because integral calculus learning activities in tertiary institutions aim

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to achieve creative abilities, scientific thinking, and reasoning (Ariawan & Nufus, 2017; Solfitri & Siregar, 2021). Learning mathematics can improve the ability to think creatively mathematically because when studying mathematics, students are trained to be able to find relationships and generalization patterns (Arhasy & Mulyani, 2017; Dwijayani, 2019). Therefore, in learning, students must be directed to carry out creative activities such as discovery, intuition based on curiosity, making conjectures, having original thoughts, daring to try, and divergent thinking.

Students' ability to think creatively and mathematically in everyday learning on campus has not been seen optimally. Students still have difficulty in answering questions about creative thinking skills. When students are given questions that can be solved in more than 1 way, students are often fixated and try to use the method of the material they recently studied. Students usually find it difficult to express more than one correct answer or different answers (Nurrita, 2018; Solfitri & Siregar, 2021). The answers given by students are tied to the material explained that day. This means that the learning provided has not been able to bring up students' mathematical creative thinking abilities. As stated by previous study the ability to think creatively mathematically cannot be achieved by students if the learning questions given are closed routine questions and only have one correct answer (Amidi, 2018). In addition to the questions given, the available teaching materials also do not facilitate the ability to think creatively mathematically because it directs students to memorize formulas or methods of solving problems with exercises in the form of routine questions (Annisah et al., 2020; Suryaningtyas et al., 2020).

Learning that is not optimal in facilitating students' mathematical creative thinking abilities has an impact on the achievement of students' mathematical creative thinking abilities. In previous studies, the results obtained were that the achievement of each indicator of the ability to think creatively mathematically was below 50%, with a low category in geometric material (Sarassanti & Mutazam, 2019). Judging from students' abilities, students with a high ability to think creatively mathematically can solve questions, and students with low ability can only solve problems for indicators of fluency. In contrast, other previous study state students with low ability cannot solve questions of mathematical creative thinking ability at all (Huljannah et al., 2018).

Problems related to students' creative activities in learning and the achievement of students' mathematical creative thinking skills need to be overcome. Several ways that can be done to overcome this problem include designing learning tools that can bring out students' mathematical creative thinking abilities, choosing learning methods that can involve students and encourage students to come up with creative ideas, and providing encouragement as well as reinforcement so that students never give up to solve non-standard questions—routinely using various methods (Anggitasari et al., 2020; Solfitri & Siregar, 2021). The provision of e-worksheets can be an alternative to overcome this problem, especially during the Covid-19 pandemic, where students must have independent learning and good self-regulation (Assagaf, 2016; Siregar & Siregar, 2021). The idea of current technological developments that prioritize flexibility can be adopted in developing e-worksheets so that worksheets can be accessed quickly, anytime, anywhere to support student independence in learning (Septinawati et al., 2020; Syafryadin et al., 2021). Therefore we need an e-worksheet that can encourage independent learning and the ability to think creatively and mathematically. Moreover, there is no e-worksheet that can assist students in optimizing their ability to think creatively mathematically in the material of Integral Integration Techniques of Rational Functions where the Denominator is a Linear Factor.

E-worksheets are another form of worksheets where e-worksheets are used using electronic devices such as gadgets or laptops. Worksheets contain guidelines, activities, problems that are arranged and adapted to the competencies that students need to achieve, and their use requires other sources as additional references (Fajarianingtyas et al., 2019; Pasandaran et al., 2017). Some advantages of e-worksheets include making students active in learning and encouraging students to search for and expand the material being studied. E-worksheets can be presented using a variety of applications that are available for free or for a fee. One of the free e-worksheet service providers is Google Docs. Besides free access, the benefits of using Google Docs are that students can discuss online while working on e-worksheets simultaneously, encourage students to study independently, train students to be disciplined, and provide storage space for student work (Dharmawan et al., 2015; Fathimah et al., 2020). The positive response from Google Docs users is that the application is practical, work can be done effectively and efficiently, and fellow users can interact to complete work simultaneously.

Based on the discussion above, it means that e-worksheets can be developed using the Google Docs application to overcome the problems of learning activities and achieve mathematical creative thinking skills that are not yet optimal. By preparing an e-worksheet that facilitates activities and achievement of each indicator of mathematical creative thinking ability, it is hoped that students' mathematical creative thinking ability will increase (Farman et al., 2021; Suryawati et al., 2020). Efforts to improve mathematical creative thinking abilities have been carried out by previous researchers and obtained quite good results

because they can improve students' mathematical creative thinking abilities. Previous research that developed worksheets filled with inquiry and Jambi culture has been able to improve students' mathematical creative thinking abilities (Febriani, 2016; Sutrimo et al., 2019). In addition, providing worksheets containing appropriate performance statements/questions in accordance with learning objectives can increase student involvement in teaching and learning activities.

Referring to the problems that occur, theories, and the results of previous research, it is necessary to develop an e-worksheet that can overcome activity problems and achieve students' mathematical creative thinking abilities. Therefore, research was conducted to develop an e-worksheet in integral calculus subject material Integral Integration Techniques of Rational Functions with the Denominators being Linear Factors. This study aimed to produce an e-worksheet that improves the ability to think creatively mathematically in the Integral Integration Technique of Rational Functions with the Denominator as a Linear Factor that meets valid, practical, and effective requirements.

2. METHODS

This research is development research, where after this research is carried out, a product is obtained that has been tested for validity, practicality, and effectiveness. The product produced in this study is an Electronic Student Worksheet (e-worksheet) on Integral Integration Techniques of Rational Functions, with the Denominator being a Linear Factor. Using Google Docs, e-worksheets are made to improve students' mathematical creative thinking skills. The research location is in Pekanbaru at the Mathematics Education Study Program at the University of Riau. The research subjects were 15 students in the Mathematics Education Study Program at the University of Riau. The stages in this study adopted the ADDIE model development research stages: Analysis, Design, Development, Implementation, and Evaluation.

The Analysis phase, the first stage of the ADDIE model, is carried out before planning to analyze students, including giving pretests, curriculum analysis, analysis of learning materials, and finding problems. After carrying out the stages of analysis, it was concluded that students need learning tools that can improve their mathematical creative thinking skills and can be easily accessed by students. Therefore, a decision was made to develop an e-worksheet that can improve mathematical creative thinking skills in the Integral Integration Technique of Rational Functions with the Denominator as a Linear Factor using the Google Docs application.

Next, the activity of designing e-worksheets in the Design stage begins. The e-worksheet on Integral Integration Techniques of Rational Functions with Denominators as Linear Factors consists of 2 e-worksheets, each for different linear and repeated linear factors. The e-worksheet that has been made is then given to 2 expert validators to be given validation assessment scores, suggestions, and improvements. The results of the validator's assessment in the form of scores, suggestions, and input are then implemented into e-worksheet improvement activities. After the e-worksheet has been repaired, the e-worksheet is then given to students in the framework of a limited trial at the Implementation stage. After students use the e-worksheet, students are then given a response questionnaire. Students are also given a posttest on the ability to think creatively and mathematically.

The Evaluation stage is the final stage of the ADDIE model research series. At the Evaluation stage, the results obtained at the Implementation stage are analyzed to determine the practicality and effectiveness of the e-worksheet. The level of practicality can be seen from the results of the student response questionnaire. While the level of effectiveness is shown by the increase in the ability to think creatively mathematically in the posttest from the pretest score. The instruments used in this study were questionnaires and tests. The questionnaire referred to in this study is a validated questionnaire that uses a Likert scale to assess the validity of the e-worksheet made and student response questionnaires after using the e-worksheet. The validation questionnaire has very appropriate, appropriate, inappropriate, and inappropriate answer choices. The available answer choices for the student response questionnaire are strongly agreed, agree, disagree, and strongly disagree. While the question test is a test of the ability to think creatively mathematically on the material of Integral Integration Techniques of Rational Functions, with the Denominator being a Linear Factor given in the form of a pretest and posttest. The test consists of 3 descriptive questions representing the ability to think creatively mathematically with fluency, flexibility, and originality.

Data was collected once on the validity of the e-worksheet and student responses after using the e-worksheet. The data collection results were then analyzed descriptively, quantitatively, and qualitatively. For validation results, a qualitative descriptive analysis was carried out on the comments and suggestions of the validator. Meanwhile, a quantitative descriptive analysis was carried out on the validation score by determining the average score for each aspect and comparing it with the following e-worksheet validity criteria (Subekti & Akhsani, 2020). The criteria is sow in Table 1.

Table 1. E-Worksheet Validity Criteria

Score	Category
$3{,}25 < \bar{x} \leq 4{,}00$	Very Valid
$2{,}50 < \bar{x} \leq 3{,}25$	Valid
$1{,}75 < \bar{x} \leq 2{,}50$	Quite Valid
$1{,}00 \leq \bar{x} \leq 1{,}75$	Not Valid

The student response questionnaire score is then calculated based on the choices made by students from numbers 1 to 4. Students choose the greater the number, the greater the level of student agreement with the statement. The analysis used for the results of the student response questionnaire was carried out quantitatively by calculating the scores obtained by students in each statement item. This data is useful to determine the practicality of the e-worksheet compiled. Furthermore, each student's score is calculated using the following formula (Akbar, 2017). The results of these calculations are categorized based on a criterion. The criterion used is show in Table 2.

Table 2. Practical Criteria

No.	Practical Percentage (%)	Practical Level
1	$0 \leq p \leq 20$	Very Not Practical
2	$20 < p \leq 40$	Not Practical
3	$40 < p \leq 60$	Less Practical
4	$60 < p \leq 80$	Practical
5	$80 < p \leq 100$	Very Practical

Base on Table 2, the following data to look at is effectiveness data. The increase in the score of mathematical creative thinking ability in the posttest from the pretest score shows the level of effectiveness. The effectiveness of the e-worksheet is obtained from the amount of n-gain, which is calculated by the following formula. The n-gain score is then determined by its category. The n-gain category used can be seen in the Table 3.

Table 3. N-Gain Criteria

N-gain (g)	Interpretation
$g \geq 0{,}7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0{,}3$	Low

3. RESULT AND DISCUSSION

Results

This research was conducted by adopting the ADDIE development research stages. Therefore, the initial stage carried out in this research is analysis. Analysis at the beginning of the study was carried out to find out the problems and needs of students in integral calculus courses. At the analysis stage, to determine students' mathematical creative thinking abilities, the researcher gave pretests to students. The pretest consists of 3 descriptive questions with a maximum total score of 12. The pretest results show that the average student's total score is only 2.73, or an achievement of 22.75%. Students' mathematical creative thinking abilities are still far from good. From observations of learning activities in class, it can be seen that students still find it challenging to express original ideas or more than one way of answering questions. Based on the results of interviews with students, students stated that they did not yet have worksheets that could direct them to think creatively. Based on this problem and current technological developments, it was decided to develop an e-worksheet that can be accessed easily and improve mathematical creative thinking skills in the material Integral Integration Techniques of Rational Functions with Denominators Are Linear Factors. E-worksheets are created by utilizing the Google Docs application to help students discuss with other friends even though they are not in the same place. This is in line with the statement that students need e-worksheets that not only help in increasing student activity but also in cognitive achievements, such as the ability to think creatively mathematically through instructions, activities, open-ended questions, and ease of access independently.

After determining the solution to overcome the existing problems, the following research stage is Designed by making an e-worksheet design in integral calculus courses for rational functions with different

linear denominators and rational functions with repeated linear denominators. At this stage, it is also determined that the e-worksheet will be directed at indicators of creative thinking fluency, flexibility, and originality. The arrangement of the e-worksheet at the beginning of planning consists of a title, identity, instructions for use, learning objectives, activities to find concepts, and questions for mathematical creative thinking exercises indicators of fluency, flexibility, and originality. The next stage of research implementation is Development. At this stage, the e-worksheet design is realized. An example of the initial display of an e-worksheet for material Integral Integral Engineering of Rational Functions with Denominators are Different Linear Factors can be seen in Figure 1.

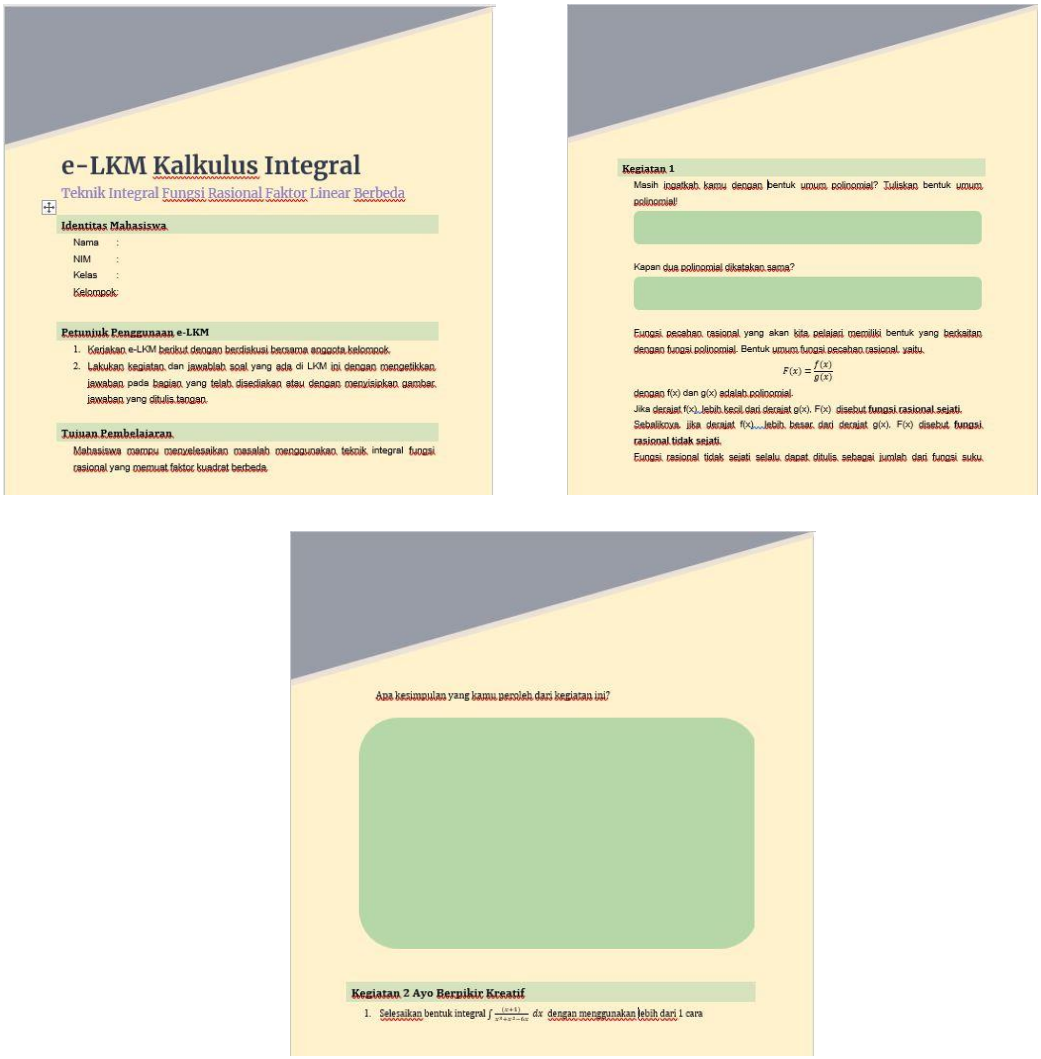

Figure 1. Initial E-Worksheet

Next, the e-worksheet that has been completed is assessed and given suggestions for input by two validators to see its validity. The improvement provided by the validator is that activities on the e-worksheet should be made by considering the indicators of mathematical creative thinking ability, namely fluency, flexibility, and originality. It is intended that the resulting e-worksheet can improve the ability to think creatively and mathematically. The revised e-worksheet display based on these suggestions can be seen in Figure 2.

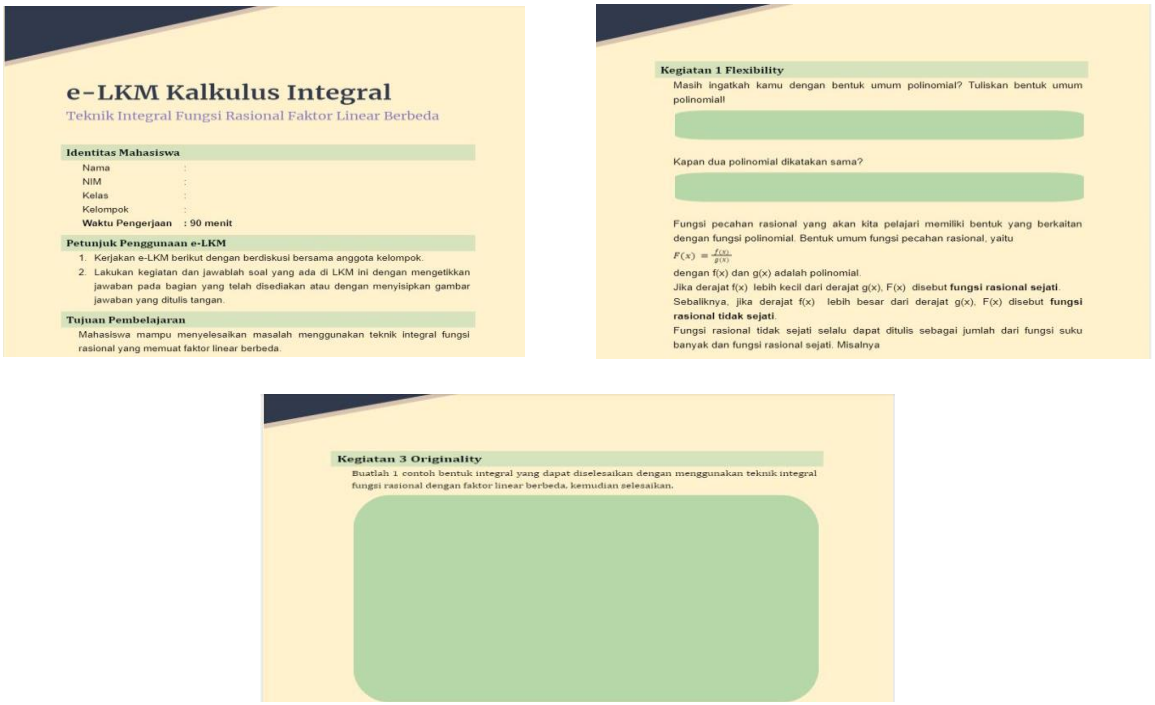

Figure 2. View of Revised E-Worksheet

After the e-worksheet has been revised according to the validator's suggestion, the revised e-worksheet is given to the validator for reassessment. The validation sheet scores of the two validators for e-worksheet one material for integral rational functions with the denominator being a different linear factor can be seen in Table 4.

Table 4. E-Worksheet Validation Score 1

No.	Aspects	Validator Score		Average	Description
		V1	V2		
1	Material	3.5	3	3.25	Very Valid
2	Learning	3.33	3.33	3.33	Very Valid
3	Mathematical Creative Thinking Ability	3	3	3	Valid
4	Physical Appearance	3.67	3.67	3.67	Very Valid
5	Language	3	3	3	Valid
6	Layout	3	3.67	3.33	Very Valid

From Table 4, it can be seen that for e-worksheet one, the integral rational function material with the denominator is a different linear factor 4 of the six aspects have obtained a score in the very valid category, while the other two aspects have received a valid category. Next, the calculation of the validation score for e-worksheet two is carried out. The validation sheet scores of the two validators for e-worksheet 2 are rational function integral materials. The denominator is a recurring linear factor, which can be seen in Table 5.

Table 5. E-Worksheet Validation Score 2

No.	Aspects	Validator Score		Average	Description
		V1	V2		
1	Material	3	3.33	3.17	Valid
2	Learning	3.25	3.5	3.375	Very Valid
3	Mathematical Creative Thinking Ability	3	3	3	Valid
4	Physical Appearance	3.33	3.33	3.33	Very Valid
5	Language	3	3	3	Valid
6	Layout	3.33	3.33	3.33	Valid

From Table 5, it can be seen that 3 of the six aspects of the e-worksheet score in the very valid category, while the other three aspects score in the valid category. It means that e-worksheet one and e-worksheet two on the Integral Integration Technique of Rational Functions with the Denominators as Linear Factors are valid and can be used by Mathematics Education students in Integral Calculus courses.

After the e-worksheet is considered valid by the validator, then the e-worksheet is tested on students. After students have finished using the e-worksheet, students are given a response questionnaire. This response questionnaire is useful for knowing student responses after using the e-worksheet so that the level of practicality of the e-worksheet can be known. Student response scores after using the e-worksheet can be seen in Table 6.

Table 6. E-worksheet Use Response Score

No.	Statement	E1			E2		
		Total	Percentage	Category	Total	Percentage	Category
1	Interesting e-worksheet	51	85	Very Practical	49	81.67	Very Practical
2	E-worksheets increases the desire to learn	48	80	Practical	43	71.67	Practical
3	E-worksheet uses a font size and shape that is comfortable to read	51	85	Very Practical	54	90.00	Very Practical
4	The e-worksheet helps to understand material on the integration technique of Integral Rational Functions, with the Denominators being Linear Factors	52	86.67	Very Practical	46	76.67	Practical
5	The e-worksheet contains challenging questions	52	86.67	Very Practical	44	73.33	Practical
6	E-worksheet directs us to think creatively	52	86.67	Very Practical	46	76.67	Practical
7	E-worksheet is easy to use	42	70	Practical	37	61.67	Practical
8	The learning experience increases after using the e-worksheet	53	88.33	Very Practical	45	75.00	Practical
9	The e-worksheet uses easy-to-understand, clear, and systematic discussion	49	81.67	Very Practical	48	80.00	Practical
	Average	**50**	**83.33**	**Very Practical**	**45.78**	**76.3**	**Practical**

Based on Table 6, the results of a questionnaire on student responses to the use of e-worksheets, overall, the two e-worksheets met the practicality criteria. The achievement of student responses to e-worksheet 1 was 83.33% with very practical criteria. For e-worksheet 2, the achievement obtained under e-worksheet one is 76.3% but still meets the practicality criteria in the practical category.

Then the testing continued on the effectiveness of the e-worksheet by giving posttests to students. From a maximum score of 12, the average student posttest is 7.6, which has increased compared to the pretest, which was 2.73. The n-gain is 0.54 and is in the moderate improvement category. This means that after being given the e-worksheet, there is an increase in students' mathematical creative thinking abilities in the medium category. Based on the results of validity, student responses and the increase in posttest scores from the pretest, it appears that e-worksheets get good results in testing validity, practicality, and effectiveness. Therefore, it can be concluded that the developed e-worksheet can be used to enhance students' mathematical creative thinking skills.

Discussion

From the calculation of the validation score, the result is that overall, e-worksheet one and e-worksheet two on Integral Integration Techniques of Rational Functions With the Denominators Are Linear Factors are valid and can be used by Mathematics Education students in Integral Calculus courses. When viewed from each aspect of validation, in e-worksheet 1, 4 aspects are in the very valid category, while the other two are in the valid category. For e-worksheet 2, 3 aspects get the very valid category, while the other three aspects get the valid category. Judging from student responses to using e-worksheets to see practicality, it can be concluded that both e-worksheets meet the practicality criteria. The achievement of student responses to e-worksheet 1 was 83.33% with very practical criteria. For e-worksheet 2, the achievement obtained under e-worksheet one is 76.3% but still meets the practicality criteria in the practical category.

Based on the validation test and student responses, it can be seen that e-worksheet 1 obtained better results than e-worksheet 2. E-worksheet 1 discussed material on the Integration Technique of Rational Functions with Different Linear Factor Denominators. While e-worksheet 2 discusses the material of Rational Function Integration Techniques with Repeated Linear Factor Denominators. E-worksheet 1 gets a higher response than e-worksheet two because the material in e-worksheet 2 is more difficult than in e-worksheet 1. In addition, the material in e-worksheet 2 is related to e-worksheet 1, so students who do not understand e-worksheet one difficulties when working on e-worksheet 2. This study's results align with previous research's results that the difficulty level of mathematics material affects students' interest in and responses to the material (Handayani & Mahrita, 2020; Kholil & Zulfiani, 2020; Susiaty, 2018).

From the results of the worksheet effectiveness test, there has been an increase in students' mathematical creative thinking abilities after using the e-worksheet. This can be seen from the rise in the average pretest score of 2.73 to 7.6 in the posttest score. The criterion for increasing the ability to think creatively mathematically is medium. An increase in the ability to think mathematically occurs because, in e-worksheet, students are facilitated to carry out activities that achieve each creative indicator, namely fluency, flexibility, and originality (Istikomah & Purwoko, 2020; Nurdin et al., 2019). The results of this study are in line with the results of previous research regarding the creation of worksheet in integral calculus courses to improve spatial abilities. In this study, the worksheet used was a printed worksheet with Geogebra-assisted, so that students' spatial abilities increased (Tonra & Salim, 2018). The results of this study also obtained positive results as in the results of previous studies, which can improve the ability to think creatively mathematically by providing open-ended questions or designing activities that facilitate the attainment of mathematical creative thinking abilities (Afandi & Jalal, 2017; Siregar et al., 2022).

The difference between this research and previous research is that in previous studies the worksheet developed were printed worksheet while the worksheet produced in this study were electronic worksheet. Furthermore, there has been the development of worksheet to improve creative thinking skills through open ended questions. However, the novelty in this research is the development of e-worksheet to optimize the ability to think creatively mathematically is not only through open ended questions but also through various activities that can optimize each creative indicator, namely fluency, flexibility, and originality. The implication of this study developed e-worksheet is feasible to use and can improve students' mathematical creative thinking abilities.

4. CONCLUSION

The result is that overall, e-worksheet one and e-worksheet two on Integral Integration Techniques of Rational Functions With the Denominators Are Linear Factors are valid and can be used by Mathematics Education students in Integral Calculus courses. Based on the results of a questionnaire on student responses to the use of e-worksheets, overall, the two e-worksheets met the practicality criteria. The achievement of student responses to e-worksheet 1 was very practical criteria. For e-worksheet 2, the achievement obtained under e-worksheet one is in the practical category. From the results of the worksheet effectiveness test, there has been an increase in students' mathematical creative thinking abilities after using the e-worksheet. This can be seen from the increase in the average pretest score of in the posttest score. The criterion for increasing the ability to think creatively mathematically is medium. Referring to the results of this study means that the developed e-worksheet is feasible to use and can improve students' mathematical creative thinking abilities.

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