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Development of STEM-Based e-Worksheets to Improve Creative Thinking Ability on the Topics of Angles

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Abstract: This research aims to develop e-worksheet learning media with a STEM approach to improve junior high school students' creative thinking skills. This research is a development research using the ADDIE model. This research was conducted at 6 Catholic private junior high schools in seventh grade. The results of this study are e-worksheets that are made to meet valid, practical, and effective aspect categories. Valid aspects are obtained through the assessment of material experts and media experts with values of 77 and 63.5 and fall into the very good and good categories. The practicality aspect was obtained through small-scale tests and large-scale tests with values of 80.17 and 75.83 and were in the good category for both. The effectiveness aspect is obtained through the results of the effectiveness test which includes paired sample t-test, one sample t-test, and mean different test. Based on the paired sample t-test for the experimental class and the control class, the results showed that there was an increase in scores before using the e-worksheet and after using the e-worksheet. Based on the one sample t-test, it was found that there was an increase in students' creative thinking abilities by using e-worksheets. The conclusion of this study is that e-worksheets with the STEM approach are effective for improving junior high school students' creative thinking abilities.

Keywords: ADDIE, creative thinking, e-worksheet, STEM.

Abstrak: *Penelitian ini bertujuan untuk mengembangkan media pembelajaran worksheet elektronik dengan pendekatan STEM untuk meningkatkan kemampuan berpikir kreatif siswa SMP. Penelitian ini merupakan penelitian pengembangan dengan menggunakan model ADDIE. Penelitian ini dilakukan pada 6 SMP Swasta Katolik di kelas tujuh. Hasil dari penelitian ini adalah worksheet elektronik yang dibuat memenuhi kategori aspek valid, praktis, dan efektif. Aspek valid diperoleh melalui penilaian ahli materi dan ahli media dengan nilai 77 dan 63,5 serta masuk pada kategori sangat baik dan kategori baik. Aspek kepraktisan diperoleh melalui uji skala kecil dan uji skala besar dengan nilai 80,17 dan 75,83 serta masuk kategori baik untuk keduanya. Aspek keefektifan diperoleh melalui hasil uji keefektifan yang meliputi paired sample t-test, one sample t-test, dan mean different test. Berdasarkan paired sample t-test kelas eksperimen dan kelas kontrol diperoleh hasil yang menunjukkan adanya peningkatan nilai sebelum menggunakan worksheet elektronik dan setelah menggunakan worksheet elektronik. Berdasarkan one sample t-test diperoleh hasil bahwa ada peningkatan kemampuan berpikir kreatif siswa dengan menggunakan worksheet elektronik. Kesimpulan penelitian ini adalah worksheet elektronik dengan pendekatan STEM efektif untuk meningkatkan kemampuan berpikir kreatif siswa SMP.*

Kata kunci: *ADDIE, berpikir kreatif, lembar kerja elektronik, STEM.*

▪ INTRODUCTION

Mathematics is one of the compulsory subjects studied in schools starting from Elementary School (SD) to high school level. Mathematics is a subject that studies abstract things, but plays an important role in supporting various fields of study because

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it can be used in the practice of everyday life. Mathematics is a lesson that uses reasoning, logic, and arithmetic skills, so through mathematics learning activities, students are expected to be able to think critically, creatively, and systematically. In other words, through mathematics learning activities, students are trained to be able to read and analyze various problems related to mathematics, so that students can find solutions to these problems (Suyitno & Suyitno, 2015). But lately, as a result of the Covid-19 pandemic, mathematics learning activities have experienced problems. Learning activities carried out through online learning make it difficult for students to understand the lesson. During the pandemic, the learning methods provided by teachers to students were limited. This happens because teachers use online and this condition hinders the development of students' cognitive, affective and psychomotor abilities in learning mathematics (Tambunan, 2021; Wijaya, 2021).

Mathematics plays a role and collaborates with various disciplines such as Natural Sciences (IPA), various approaches, various methods, models, as the application of learning techniques, ideas, skills, creativity, and as a form of problem solving that leads to a new perspective in learning activities called STEM (Barret et al., 2014). The STEM approach in learning mathematics has the characteristics and goals of collaborating with more than one subject that is involved and focuses on the solutions offered to everyday problems (English & King, 2015). In addition, the STEM approach is also a stage for combining several strategies so as to provide a form of learning that covers various sectors (Ismayani, 2016). The STEM approach also helps students to experience mathematics learning that focuses on a process of discovery rather than the end result of the discovery itself. Through the STEM approach, students learn to solve problems, become innovators, creators, and collaborators. This condition is an important highlight for the future of the Indonesian nation (Gustiani et al., 2017). In addition, the STEM approach presents meaningful learning activities that direct students to find something based on experience, increases motivation in learning, links theory with practice in the field, provides solutions to mathematical problems, and increases the sensitivity of knowledge to solve everyday life problems using mathematics. (Altakahyneh & Abumusa, 2020).

The application of STEM to learning mathematics in this study is presented through lines and angles material at the junior high school level. This combination of science, technology, engineering, and mathematics encourages students to find solutions to given mathematical problems, so that learning becomes more meaningful (Michaluk et al., 2018). The STEM approach can be applied using learning media, teaching aids, and e-worksheets. Objects that can be used in mathematics learning activities with the STEM approach are e-worksheets or commonly called e-worksheets designed using the ADDIE development model. This e-worksheet is one of the many media that can be used to convey learning material in a more directed, systematic manner, and of course it can achieve the planned learning objectives (Angraini et al., 2021). Electronic worksheet is one of the teaching materials that teachers and students really need in learning activities because it can simplify and shorten time, so that learning activities become more effective (Suryaningsih & Nurlita, 2021). In addition, students also have the potential to improve creative thinking skills that can be developed in the learning process. This e-worksheet facilitates students' creative thinking skills because through STEM collaboration, students are very free to express their ideas (Fredagsvik, 2021).

Some students have difficulty understanding mathematical concepts, mathematical problems, and finding solutions to the answers to the problems given. Various kinds of solutions can be used to overcome this condition, one of which is by presenting material and math problems on e-worksheets (worksheet). In uncertain situations, e-worksheet makes it easy for students to study wherever and whenever. The purpose of using this e-worksheet is to increase student learning activities and make it easier for students to understand the material provided, enrich problem solving exercises, and train student independence (Haryonik & Bhakti, 2018). This e-worksheet can be accessed anywhere, reduces the use of paper, and of course is designed using the latest technology. Electronic worksheet is made by developing existing manual worksheet by adding various features that students can use to support material understanding in mathematics learning activities. The need for the development of e-worksheets is adapted to the conditions of students who feel bored when learning mathematics and the demands for innovation in technological developments. This e-worksheet was made using the Canva software so it has lots of interesting pictures and illustrations as well as the help of a liveworksheet site. With this e-worksheet, students are expected not to feel bored (Baya'a & Daher, 2013). This aims to improve learning achievement and students' critical thinking skills. In addition, this e-worksheet was made because it adapts to the current era of learning and refinement of the 2013 curriculum, where teachers are also required to integrate ICT in the learning process (Altakahyneh & Abumusa, 2020).

▪ METHOD

Participants

The population in this study were all Catholic private junior high school students in the Special Province of Yogyakarta. There are 13 schools with a total of 416 students. The sample in this study were 6 schools which were taken randomly through the Wheel of Names. Based on the results of the draw, the samples were obtained from SMP Pangudi Luhur 1 Yogyakarta, SMP Stella Duce 2 Yogyakarta, SMP Kanisius Gayam, SMP Maria Immaculata Marsudirini, SMP Joannes Bosco, and SMP Kanisius Pakem. Many of the research samples involved were 192 students from the 6 schools.

Research Design and Procedures

This research is a developmental research with the following steps: (1) Conducting preliminary research which includes field observations and teacher interviews to make agreements on the materials used. (2) Making products in the form of e-worksheet, conducting material validation tests and media validation tests for class teachers and media experts. (3) Conduct small and large scale tests with the aim that the products used can achieve research objectives. (4) Carry out learning activities for 4-5 meetings, ending with a summative test and filling out a questionnaire. The development research design was carried out using the ADDIE model which is a model that is generally used to design learning guides so that the resulting learning designs are more effective (Widyastuti & Susiana, 2019). The ADDIE model uses the Analysis, Design, Development, Implementation, Evaluation syntax. In the analysis section there are steps of curriculum analysis, material analysis, student character analysis, and learning problem analysis. In the design section there are steps for designing learning materials using the STEM approach, RPP designs, and e-worksheet prototype designs.

In the development section there are product development steps, expert validation tests, and small group trials. In the implementation section there are steps for the large group trial stage. In the evaluation section, there is an assessment step for the e-worksheet that has been constructed.

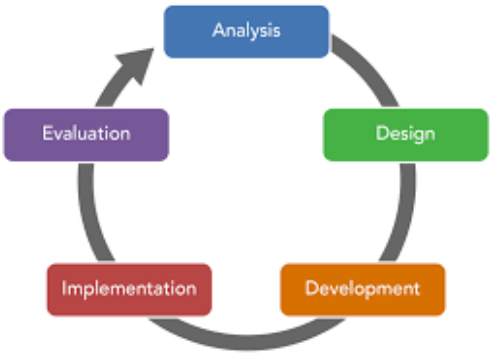

Figure 1. ADDIE diagram

Through the process of this learning activity, students are expected to be able to carry out all steps of problem solving properly and structured in order to get solutions to existing problems. This process directs students to be able to think creatively and construct the knowledge they already have, collaborate with learning activities and new experiences, so that students can learn more easily because they have a lot of information (Fithri et al., 2021). In addition to creative thinking skills, through the learning process using this e-worksheet, students' cognitive abilities are expected to increase, so that students' learning achievement in mathematics becomes better. In this study, indicators of creative thinking skills that will be observed are Fluency, Flexibility, Originality, and Elaboration. This research was conducted for three weeks from 20 October 2022 to 10 November 2022.

Instruments

The instruments used in this study include test and non-test instruments. The test instruments used were pretest and posttest questions. There are 4 test questions given for both pretest and posttest to measure fluency, flexibility, originality, and also elaboration. The non-test instruments used were material expert questionnaires, media expert questionnaires, and student response questionnaires. There are 16 items that must be assessed by material experts, 14 items that must be assessed by media experts, and 20 statements that must be filled out by students through a questionnaire.

Data Analysis

This research is said to be successful if the e-worksheet is declared valid, practical and effective. In addition, this research is said to be successful if the e-worksheet used in learning activities has an influence on student achievement and students' creative thinking skills. In addition, student achievement increases and students' creative thinking skills are at least in the good category.

Table 1. Classification of validity and practicality criteria

No	Score	Criteria
1.	$\bar{x} > \bar{x_i} + 1{,}8sb_i$	Very good
2.	$\bar{x_i} + 0{,}6sb_i < \bar{x} < \bar{x_i} + 1{,}8sb_i$	Good
3.	$\bar{x_i} - 0{,}6sb_i < \bar{x} < \bar{x_i} + 0{,}6sb_i$	Enough
4.	$\bar{x_i} - 1{,}8sb_i < \bar{x} < \bar{x_i} - 1{,}6sb_i$	Less
5.	$\bar{x} < \bar{x_i} - 1{,}8sb_i$	Very less

Where $\bar{x}$, $\bar{x_i}$, and sb_i are validity score, ideal average, and standard deviation. The effectiveness test in this study used the normality test and homogeneity test. Electronic worksheets are declared practical if the normality test results have a significance value of more than 0.05 and the data comes from a normally distributed population. Electronic worksheets are declared practical if the results of the homogeneity test have a significance value of more than 0.05. Another test used is the paired sample t-test. This test is carried out because there are 2 hypotheses to be tested.

Hypothesis 1:

H_0 : There is no effect of the use of e-worksheets on student achievement through the STEM approach

H_1 : There is an effect of the use of e-worksheets on student achievement through the STEM approach

Hypothesis 2:

H_0 : There is no effect of the use of e-worksheets on students' creative thinking abilities through the approach STEM

H_1 : There is an effect of using e-worksheets on students' creative thinking abilities through the STEM approach

▪ RESULT AND DISSCUSSION

This research is a development research using the ADDIE model which uses the STEM approach to improve students' creative thinking abilities. The ADDIE model is one of the instructional design models that has been used to develop curricula in areas such as library instruction and continuing online education (Cheung, 2016). The product resulting from this research is an e-worksheet which is an appropriate learning tool both theoretically and empirically needed to train creative thinking skills that are useful in problem solving (Badriyah et al., 2021). This e-worksheet has various components and learning materials that students must master through the learning process. This e-worksheet has certain characteristics so that it fits the needs and conditions of students (Suhono & Sari, 2020). There are stages of analyzing student learning needs, especially in post-pandemic conditions. The learning approach taken during the pandemic did not have a significant impact on learning activities, so it is necessary to have another learning approach that is able to overcome problems in the objectives of learning activities.

In addition, analysis is also carried out to anticipate the existence of worksheets that are less useful and will actually hinder learning activities. The initial step taken in the manufacture and development of e-worksheets is to design learning activities that will be carried out using the STEM approach. This design includes learning objectives, scenarios of learning activities, learning devices used, teaching materials delivered, and learning evaluation tools. The integration of science and technology plays an important role in creating the needs of today's society. Therefore, the application of STEM learning was chosen to achieve the objectives of this study (Suwarma & Kumano, 2019). In addition, the purpose of making e-worksheets is to improve students' creative thinking, therefore it is necessary to develop solutions and achieve goals (Firman et al., 2016. The development stage is carried out in order to realize the design of e-worksheets that will be used in learning activities. It is hoped that this is ready to be implemented in learning activities and can facilitate students to achieve learning goals, improve achievement, and students' creative thinking skills. The implementation phase is carried out by applying the design of the STEM learning approach in an e-worksheet. After implementing this design, feedback from students is very needed to update the next e-worksheet.The evaluation phase is carried out using formative evaluation and summative evaluation.Formative evaluation is carried out at the end of the daily meeting, which is carried out during the learning process of a unit/ chapters/competencies take place, and can be done at the beginning or throughout the learning process. While summative evaluation is carried out after the learning activities end. Therefore, the ADDIE learning model is a recommended model to apply (Yeh & Tseng, 2019).

Table 2. Summary of activities for making elektronik worksheets with the addie model

Steps	Activities
Analyse	Identifying elektronik worksheets appropriate to student goals, learning objectives, content of learning materials, learning environment, and learning approaches used.
Design	Designing elektronik worksheet concept which different from usual and made in detail.
Development	Developing required elektronik worksheet according to design has been made and create instrument to measure the performance of elektronik worksheet.
Implementation	Using elektronik worksheets have been created in learning activities and reviewing learning objectives, learning materials, and learning approaches used.
Evaluation	Looking back at the impact resulting from the use of elektronik worksheets on learning activities. Measuring the achievement of using elektronik worksheets and student learning objectives. Dig deeper information about the causes of achievement of learning objectives.

Product validation is carried out to ensure that e-worksheets are valid and measurable so that they can be used in learning activities. Validation was carried out in two parts, namely material expert validation from mathematics teachers in each school and media expert validation from colleagues who are experts in learning media.

Electronic worksheets created contain problem-based learning activities (Mawaddah et al., 2015) which are modified to encourage students to think creatively (Moma, 2015).

The results of the material validation from validator 1 stated that the cover of the e-worksheet was requested to be revised using images that are relevant to the material being taught. In addition, validator 1 also states that in drawing parallel lines, the angles formed must be named. Validator 2 provides input to add practice questions so students get lots of math problems to solve. Validator 3 said that the questions that guide students in solving the given mathematical problems are expected to be structured so that students' minds can be constructed mathematically well (Bybee, 2013; Celestin & Steve, 2018). Validator 4 provides input that the video used in the live worksheet should be a video that comes from everyday life that is close to students. Validator 5 requests that there are not too many routine questions given, focus on delivering material so that students can understand the concept of angles and achieve learning targets. Validator 6 expects that the images used are not from animated cartoons but images that are true to reality. The results of the material expert validation obtained an average score of 77 in the very good category. The results of media validation by the validator have an average score of 63.5 in the good category. The suggestions and input given by the media expert validator are that coloring that is too diverse can be reduced so that students can focus on the material. In addition, the symbols used should not be monotonous and must be varied. There is also a suggestion that you have to be careful when placing pictures and sentences so that they don't get messy when uploaded to the liveworksheet. The results of the validation of material and media experts state that this e-worksheet is valid for use.

This e-worksheet was tested on a small scale with a total of 18 students in each school as a sample. The total results of small-scale trials were 481 and the average was 80.17 which was in the good category. Large-scale tests were attempted on students from each school to measure the practicality of e-worksheets. The average score of the large-scale trial obtained was 75.83. This result is in the good category, so this e-worksheet is practical to use.

The effectiveness of e-worksheets is analyzed based on the results of the summative evaluation given at the evaluation stage. At the evaluation stage, e-worksheets are used in learning activities to measure students' creative thinking skills through pretest and posttest because creative thinking skills will help students understand abstract mathematical topics (Wijaya et al., 2021; Beghetto & Kaufman, 2014). Statistical test were performed in the following way: first, Normality and homogeneity test. The normality test used is the Kolmogorov-Smirnov test on the results of the pretest and posttest in the experimental class and the control class. The results of the normality test show that the data in both classes are normally distributed with a significance value of more than 0.05. The homogeneity test used is the Levene Statistical Test on the results of the pretest and posttest in the experimental class and control class. The results of this test indicate that the data in the two classes are homogeneous with an average test significance value of more than 0.05.

After normality and homogeneity test, the next is effectiveness test using paired sample t-test, one sample t-test, mean difference test. Paired sample t-test was used to compare the averages of two variables in one group. This analysis aims to test whether e-worksheets have an effect on creative thinking skills. Based on the paired sample t-

test for the experimental class, it was found that the value of t. count > t. table (13.777 > 2.021). So, the hypothesis is rejected. This shows that there is a difference in the average pretest and posttest scores in the experimental class. The average value of the pretest results for creative thinking skills before using e-worksheets is 33.3333 while the posttest average scores for creative thinking skills after using e-worksheets are 76.7857. This condition indicates an increase in results before using e-worksheets and after using e-worksheets in the experimental class. Based on the paired sample t-test for the control class, the results showed that the value of t. count > t. table (7.643>2.021). So, the hypothesis is rejected. This shows that there is a difference in the average pretest and posttest scores in the control class. The average value of the pretest results for students' creative thinking skills before using an e-worksheet was 36.0119 while the posttest average score for creative thinking skills after using an e-worksheet was 58.9286. This condition indicates an increase in students' creative thinking skills before using e-worksheets and after using e-worksheets in the control class. This effectiveness test was conducted to find out which conditions were more effective on students' creative thinking abilities. This test compares the average value of the experimental class and the average value of the control class. Creative thinking skills train students to develop ideas and arguments, ask questions, state correct arguments, and influence students to think openly and be more responsive to different views (Yayuk et al., 2020). The one sample t-test showed that Ho was rejected so that e-worksheets were more effectively used to improve students' creative thinking abilities. The effectiveness test is also to determine the average difference in the increase in pretest and posttest scores in the experimental class and the control class. The average value increase in the control class was 22.9167 while in the experimental class it was 43.4524. So, it can be concluded that e-worksheets can improve students' creative thinking skills. Electronic worksheets have been said to be feasible because they meet valid, practical, and effective criteria (Hasibuan et al., 2019).

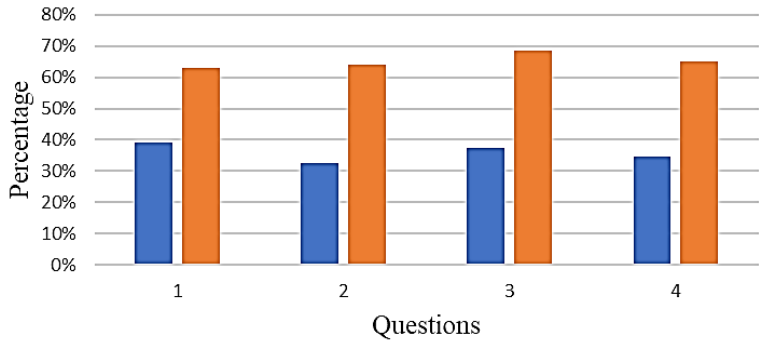

Figure 2. N-gain score for each pretest and posttest question in experimental (orange) and control groups (blue)

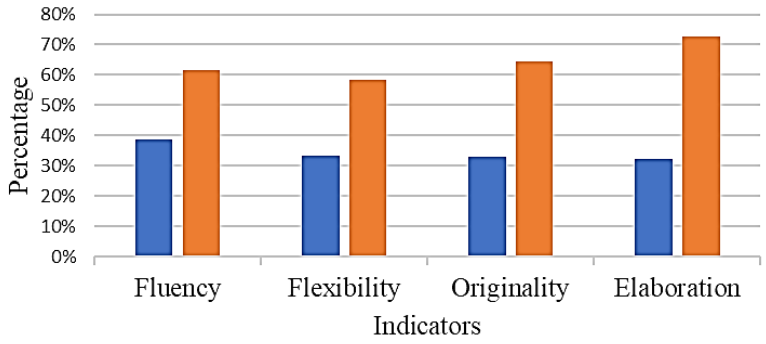

Figure 3. N-gain score for creative thinking indicators in experimental (orange) and control groups (blue)

▪ CONCLUSION

E-worksheet was developed using the ADDIE model using the STEM approach with the aim of improving junior high school students' creative thinking skills. e-worksheets meet valid criteria based on material experts in the very good category and media experts in the good category. e-worksheets meet practical criteria based on small-scale test results in good categories and large-scale test results in good categories too. The e-worksheet meets the effective criteria based on the posttest results with higher scores in the experimental class than the control class.

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