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**Development of STEM-Based LKPD (Science, Technology, Engineering, and Mathematics) on the Theme of “My Home Electrical Circuit” to Improve Critical Thinking Skills**

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**Abstract**

One comprehensive and integrated learning approach is the STEM approach. This approach can improve students' critical thinking skills if supported by teaching materials, one of which is LKPD. This study aims to produce a valid, practical, and effective STEM-based LKPD product to improve students' critical thinking skills. The method used in this study is the research and development method. A validity test has been carried out consisting of a product validity test that is declared valid and suitable for use with a percentage of 80.9%. Practicality tests conducted by teachers obtained an average result of 83% and students of 87%. The effectiveness test is carried out with an n-gain test and an effect size test. Each of them obtained a result of 0.68 in the medium category and 2.7 in the high category. So, it can be concluded that STEM-based LKPD is effective in improving students' critical thinking skills.

**Keyword**: LKPD, STEM approach, critical thinking

**Pengembangan LKPD Berbasis STEM (*Science, Technology, Engineering, and Mathematics*) pada Tema “Rangkaian Listrik Rumahku” untuk Meningkatkan Keterampilan Berpikir Kritis**

**Abstrak**

Salah satu pendekatan pembelajaran yang bersifat komprehensif dan integratif adalah pendekatan STEM. Pendekatan tersebut mampu meningkatkan keterampilan berpikir kritis siswa jika didukung dengan bahan ajar salah satunya adalah LKPD. Penelitian ini bertujuan untuk menghasilkan produk LKPD berbasis STEM yang valid, praktis, serta efektif untuk meningkatkan keterampilan berpikir kritis siswa. Metode yang digunakan dalam penelitian ini adalah metode research and development. Telah dilakukan uji validitas yang terdiri atas uji validitas produk yang dinyatakan valid serta layak digunakan dengan persentase 80,9%. Uji kepraktisan yang dilakukan guru diperoleh hasil rata-rata 83% dan siswa sebesar 87%. Uji efektivitas dilakukan dengan uji n-gain dan uji effect size. Masing-masing diperoleh hasil 0,68 dengan kategori sedang dan 2,7 dengan kategori tinggi. Sehingga dapat disimpulkan bahwa LKPD berbasis STEM efektif dalam meningkatkan keterampilan berpikir kritis siswa.

**Kata kunci**: LKPD, Pendekatan STEM, berpikir kritis.

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**INTRODUCTION**

The education unit in the 21st century is expected to be able to produce quality human resources, have skills, and are ready to compete (Mushthofa et al., 2021). UNESCO states that one of the must-haves 21st-century skills is critical thinking. Similarly, the Partnership for 21st Team also revealed that in the next five years the skills needed, one of which is critical thinking with a percentage of (Sayekti & Suparman, 2019).

Critical thinking is a skill to solve problems by analyzing, making decisions, and evaluating the arguments he expresses (Wardhani et al., 2016). In line with this opinion, Satriani (2017) revealed that critical thinking is thinking that is carefully conceptualized and asks things in a way that makes sense. The benefits of critical thinking in life are being able to think outside the bounds of out-of-the-box (creativity), create new ideas (originality), and heed social problems around (sensitivity) (Moore, 2013). According to Ennis, there are five groups of critical indicators are:

1. Elementary clarification consists of three indicators are:
2. Focus on the question, including providing a formulation of the problem, being able to consider possible answers, and cultivating thinking conditions.
3. Identifying arguments/opinions, including identifying the conclusions of a problem, analyzing the reasons, and providing solutions to errors or problems.
4. Clarifying through question and answer.
5. The basis for a decision, consists of two indicators are:
6. Review reference sources.
7. Observations and consider the results of observations.
8. Inference, consists of three indicators include:
9. Deduction and reviewing the results.
10. Induction and reviewing the results.
11. Formulate and determine the results of the review.
12. Advanced clarification consists of two indicators include:
13. Defining terms and considering such definitions.
14. Identifying assumptions.
15. Supposition and integration, includes two indicators are:
16. Considering doubtful assumptions or reasons in our thinking.
17. Combining proficiency and character in decision-making.

This critical thinking skill is needed in the future because life problems will be much more complicated, complex, and heavy so critical thinking skills are needed in solving these problems (Mushthofa et al., 2021). The same thing is also said by Setyawati et al., (2020) that critical thinking skills are recognized as being able to support the success of working and living in the present or future era. Reporting from Mushthofa et al., (2021) that students who have good critical thinking skills will find it easier to grasp various difficulties in the subject matter. This makes it clear that critical thinking skills are very important for students to have and can be developed through the learning process (Cahyono, 2017).

The learning process that can hone students' critical attitudes can be applied through comprehensive learning santoso & mosik (2019) and integrative (Shabila et al., 2020). One of the comprehensive and integrative learnings is the STEM approach. Science, Technology, Engineering, and Mathematics (STEM) is a comprehensive approach and combines four disciplines (Simatupang et al., 2019). The STEM approach provides lessons and familiarizes students with always engaging in observation/investigation activities, critical thinking, collaboration, problem solving, and design engineering (Torlakson, 2014). In general, the application of stem approaches in learning according to Fitri (2020); Kapila & Iskander (2014) is useful for cultivating (1) manipulative, affective, creative, and logical skills, (2) sharpening cognitive abilities, (3) getting used to being close to technology, and (4) solving abstract and complex problems. According to Bruton (2017); Davidi et al., (2016) objectives of the STEM approach are:

1. Science or natural science invites students to foster critical investigation, observation, or experimentation, and understanding and interest related to material, physical, or natural phenomena in physics, biology, and chemistry.
2. Technology encourages students to expand skills, help needs, and ease work and desires through the application of computational knowledge and thinking.
3. Engineering has a definition as the ability or skill in designing and compiling equipment/machines to solve problems in everyday life.
4. Mathematics as a science related to the operation of numbers, forms, and relationships can help in forming models, simplifying problems, interpreting and analyzing information/data, assessing risks, describing abstract and concrete problems, and solving problems.

The STEM approach applied in learning according to Novidya & Kustijono (2019) and Ritonga (2021) can hone students' critical thinking skills. This is recorded by the combination of the four disciplines that provide opportunities for students to determine decision making, identify and analyze arguments, solve a problem, evaluate, investigate something (Davidi et al., 2016) and make a conclusion (Mushthofa et al., 2021). Thus, it can be concluded that the four aspects of STEM can hone critical thinking skills according to Ennis.

The application of the STEM approach makes students indirectly required to think critically because in STEM activities they are accustomed to finding their thoughts (Santoso & Mosik, 2019). To improve students' critical thinking skills through a STEM approach, teachers will use various kinds of teaching material assistance during the teaching and learning process, one of which is LKPD. LKPD is useful for fostering students' thinking skills and activities, for example analyzing observational data (Shabila et al., 2020). The use of LKPD is expected to be able to develop material concepts and learn independently (Aprilianti & Astuti, 2020).

The STEM approach combined with LKPD will provide opportunities for students during activities to identify problems according to what is given (Arrohman et al., 2022). STEM-based LKPD has an influence on the cognitive and affective aspects of students (Santoso & Mosik, 2019) and encourages students to build an intellectual attitude in critical thinking, thinking deeply to solve problems, and understanding the concept of science and its relationship in everyday life (Simatupang et al., 2019).

Based on the results of observations made during the internship at SMPIT Ihsanul Fikri, it was found that the learning tools in science subjects used in general already refer to the 2013 curriculum. The teaching materials used are not varied and have not stimulated critical thinking skills. This has an impact on daily test scores, many students get KKM limit scores and some even below KKM. Learning outcomes and critical thinking skills have a positive and significant relationship according to research, if critical thinking increases where learning outcomes also increase (Youllanda et al., 2020). So, it can be concluded that the critical thinking skills of students at SMPIT Ihsanul Fikri have not been maximized.

Seeing these problems encourages authors to make innovative teaching materials that integrate critical thinking skills according to student needs. Given, that students' critical thinking skills can be effectively improved using STEM-based LKPD (Hasanah et al., 2021). So, the author is interested in developing teaching materials in the form of STEM-based LKPD which are used in the learning process on dynamic electrical materials. Furthermore, the purpose of this development research is to produce STEM-based LKPD products that are valid, interesting, easy, useful, and effective for improving students' critical thinking skills, especially in dynamic electrical materials.

**RESEARCH METHODS**

The research method used is research and development (RnD). The development carried out is the development of Student Worksheets (LKPD) developed with STEM-based to improve students' critical thinking skills in Dynamic Electricity material. According to Sugiyono (2015) this development model or called ADDIE consists of five stages which include:

(1) Analysis. At this stage, a needs analysis and curriculum analysis are carried out. The needs analysis was carried out to collect the existing conditions in a school, namely SMPIT Ihsanul Fikri. It aims to find out whether STEM-based LKPD development is needed to improve student's critical thinking skills on Dynamic Electricity material. Curriculum analysis aims to select and compile material to be contained in the LKPD based on core competencies, basic competencies, and indicators by the revised 2013 curriculum so that the suitability of the material to be included in the STEM-based LKPD is obtained.

(2) Design. The design stage is the planning stage for the preparation of a STEM-based LKPD structure framework. The structure of the LKPD includes the entire content of the LKPD by the material raised. This step is useful for compiling LKPD that is following the criteria of a good and correct LKPD so that it is suitable for use in learning. Where in its preparation it is also adapted to the STEM approach. The components developed in the LKPD include a cover page, table of contents, instructions for use, core competencies and basic competencies, learning indicators, learning objectives, STEM-based student activities, integrated evaluation questions of critical thinking skills, and a bibliography.

(3) Development. At this stage, the researcher revises the product based on the validator's assessment. This assessment aims to determine the validity of STEM-based LKPD products. The first product (prototype I) will be repaired according to the directions and input of the validator. Furthermore, the product is evaluated first and produced in LKPD Phase 2 / prototype II, which will then be tested on students.

(4) Implementation. The implementation stage is an activity to test prototype II to students with a Pretest-posttest One Group design. In testing, the items of the pretest and post-test questions were tested first by expert validators, and the reliability of the questions to class X students at SMK Muhammadiyah Bandongan. Prototype II was tested on class IX D students at SMPIT Ihsanul Fikri, Magelang City to find out the effectiveness and practicality of STEM-based LKPD.

(5) Evaluation. The evaluation stage is an activity to evaluate prototype II that has been tested on students. Assessment can be seen based on validity (feasibility), effectiveness in improving students' critical thinking skills, and practicality through teacher and student responses to the use of STEM-based LKPD. Improvements are needed if the input is found from teachers and students in filling out the practicality test questionnaire. Thus, the final product in the form of STEM-based LKPD was obtained.

Research population class IX SMPIT Ihsanul Fikri. The study sample was class IX D as many as 26 students as respondents in testing the effectiveness of STEM-based LKPD. Sample sampling using a purposive sampling technique. The techniques and instruments in this study include the LKPD feasibility instrument, the critical thinking skills test instrument, and the practicality instrument.

The feasibility of LKPD was assessed by Ashli by the Likert scale method. Here are the eligibility criteria (Akbar, 2013).

Table 1. LKPD Eligibility Criteria

|  |  |  |
| --- | --- | --- |
|

|  |
| --- |
| **Criteria** |

 | **Percentage** |
| Very Valid or can be used without revision | 85, 01% ≤ P ≤ 100% |
| Valid or usable with minor revisions | 70,01% ≤ P ≤ 85% |
| Less Valid or large revisions are required and advised not to be used | 50,01% ≤ P ≤ 70% |
| Invalid or should not be used | 1% ≤ P ≤ 50% |

The critical thinking indicator used is the Ennis indicator and uses only three indicators elementary clarification, the basis for a decision, and inference. The test instrument in the form of a description question totals 6 questions. the questions were tested for validity by validators and the reliability test was tested on 20 students.

Statistical testing to calculate the items of the pretest and posttest questions according to the prerequisite tests (normality test and homogeneity test), T-test, N-Gain test, and Effect Size test.

1. Test prerequisites
2. Normality test

The normality test is used in testing normal or not distributed data conditions so that population characteristics can be investigated. The results of data normality assisted by SPSS 25.0 using Shapiro-Wilk obtained that the α > 0.05 is α = 0.100 for pretest data and α = 0.066 for posttest data. So, it can be concluded that the distributed data is normal.

1. Homogeneity test

Homogeneity tests are used in testing variants in the same or different experimental groups. The results of the homogeneity test that have been calculated using Microsoft Excel 2016 obtained the value of F-count = 2.81 and the value of F-table = 4.23 so that the F-count ≤ F-table with α = 0.05. Thus, it can be concluded that the variant of pretest data is the same as the variant of post-test data so both samples are homogeneous.

1. Uji-T

Data on the results of students' critical thinking skills that have been tested for normality and homogeneity show that the distributed data is normal and homogeneous. It can be concluded that the data is parametric. Thus, a T-test can be carried out using a paired t-test sample assisted by SPSS 25.0. Based on the paired sample t-test with a significant value of α = 0.05, the results of the sig value were obtained. (2-tailed) by 0.000 < 0.05. That is, H0 is rejected, and Ha is accepted. The T-test in this study concludes that there are differences in students' critical thinking skills before or after using STEM-based LKPD on class IX dynamic electrical materials at SMPIT Ihsanul Fikri.

1. Uji N-Gain

Critical thinking skills analysis test using a pretest, posttest, gain, and N-Gain results. The categories in determining the improvement of students' critical thinking skills based on the acquisition of gain scores are (Hake, 2019).

Table 2. N-Gain Value Criteria

|  |  |
| --- | --- |
| **Criteria** | **Score/Result** |
| g ≥ 0,7 | High |
| 0,7 > g ≥ 0,3 | Medium |
| g < 0,3 | Low |

1. Test effect size

The effect size test aims to determine the magnitude of the effectiveness scale of STEM-based LKPD on students' critical thinking skills. Based on the results of the calculation of the magnitude of the effect size, it can be known according to the criteria below (Yuberti & Saregar, 2017).

Table 3. Effect Size Criteria

|  |  |
| --- | --- |
| **Effect Size** | **Category** |
| D < 0,2 | Low |
| 0,2 < d < 0,8 | Medium |
| D > 0,8 | High |

STEM-based LKPD practicality test was conducted to determine the responses of teachers and students to the practicality of the product. After the data were analyzed using the Likert scale method, results were obtained that showed the LKPD category. These categories can be described in the following table.

Table 4. Teacher and Student Practicality Test Categories

|  |  |
| --- | --- |
| **Category** | **Percentage** |
| Very Practical | 80% - 100% |
| Practical | 60% - 79% |
| Pretty Practical | 40% - 59% |
| Less Practical | 20% - 39% |
| Impractical | 0% -19% |

**RESULTS AND DISCUSSION**

The feasibility of STEM-based LKPD is obtained based on validity tests conducted by validators with 3 aspects of assessment, namely content aspects, presentation aspects, and linguistic aspects. The following Table 5 shows the results of validator assessments.

Table 5. Validator Assessment Results

|  |  |  |  |
| --- | --- | --- | --- |
| **Assessment aspects** | **∑Average** | **Percentage (%)** | **Category** |
| Content Aspects | 4,10 | 82% | Valid |
| Presentation Aspects | 3,71 | 74% | Valid |
| Linguistic Aspects | 4,40 | 88% | Valid |
| **Sum of all scores** | **4,04** | **80,9%** | **Valid** |

Based on table 5, STEM-based LKPD in the linguistic aspect has the highest percentage with 88%, followed by the content aspect with 82%, and 74% for the presentation aspect. The results of the overall assessment of STEM-based LKPD by the two validators obtained an average of 4.04 equivalent to an eligibility percentage of 80.9% so they are included in the valid category or can be used with minor revisions.

The presentation aspect gained a percentage of 74% with valid categories. Aspects of the presentation include the completeness of the LKPD, the collapse and clarity of the LKPD proposal, the consistency of the layout, and the attractiveness of the appearance of the LKPD. The content aspect has a percentage of 82% with valid categories. The content aspect according to Fitriyah & Wardana (2019) must be following the competencies in the applicable curriculum. Thus, the content aspects in this STEM-based LKPD are by KI and KD in the curriculum, the material delivered is following learning objectives, the material presented leads to STEM aspects and supports the improvement of students' critical thinking skills. The validity category with the highest percentage, namely the linguistic aspect, is 88%. This can be achieved because the preparation of STEM-based LKPD pays attention to PUEBI. In addition, the language used is communicative, straightforward, and effective so that an LKPD is formed that is easily understood by students following the research of Fitriyah & Wardana (2019) which states that an LKPD must use communicative sentences by PUEBI to make it easier for readers Pangesti et al., (2017) explained that teaching materials or LKPD must include clarity and accuracy of the information, readability, and suitability of language use according to the rules.

The improved STEM-based LKPD which can be said to be the final product was tested on class IX D students at SMPIT Ihsanul Fikri to find out the effectiveness and practicality. The test sheets used as a measure of students' critical thinking skills have gone through stages of validity and reliability. Validity results were obtained by 80% with valid categories and reliability results were obtained by results of 0.808 with high-reliability categories. The results of the prerequisite test, namely the normality and homogeneity test, obtained that the distribution of pretest and posttest data is normally distributed and homogeneous. Thus, it can be concluded that the data is parametric and can be done T-Test paired sample test. The results of the T-test show that Sig. (2-tailed) is 0.000 with a significance level of 0.05. According to calculations, if 0.000 < 0.05, it can be concluded that there is a difference in the students' pretest and posttest scores. If there is a difference in the results of the pretest and posttest, the product can be said to be effective (Fitriyah & Wardana, 2019). The difference in critical thinking skills can be seen in the acquisition of the average value of the pretest and posttest in the following chart.

Chart 1. Pretest and Posttest Average Score

The N-Gain test was conducted to determine the magnitude of the improvement in critical thinking skills in students after using STEM-based LKPD. The results of the N-Gain test yielded a value of 0.68 with moderate criteria. Then, the effect size results show a value of 2.7 with high criteria. The improvement of each indicator of students' critical thinking skills is presented in the following chart.

Chart 2. Average Indicators of Students' Critical Thinking Skills

The elementary clarification indicator increased by 13.5 with an average n-gain value of 0.30 belonging to the moderate category. This indicator is experiencing the lowest increase. The inference indicator increased by 20.5 with an n-gain value of 0.37 belonging to the moderate category. Then, the basis for the decision indicator increased by 29 with an n-gain value of 0.43 with a moderate category. Learning by using STEM trains students to conclude, students can conclude correctly and the conclusions made are relevant according to the concept of the material presented (Ritonga, 2021). In addition, STEM accustoms students to always make conclusions, so that students get used to conclusions (Fadlina et al., 2021). Then, the STEM approach trains students to think critically in making their decisions (Khoiriyah et al., 2018).

The LKPD developed has integrated STEM. Integration of STEM aspects allows students to connect the four disciplines, namely science, technology, engineering, and mathematics in learning activities (Ananda & Salamah, 2021). This can train students to analyze and express new ideas logically, systematically, and critically (Choiriah, 2019). In addition, ongoing learning is also able to cultivate students' scientific thinking skills (Agustina et al., 2020).

Based on the results of the n-gain and effect size tests, it can be concluded that the use of STEM-based LKPD is declared effective in improving critical thinking skills if there are differences before and after using LKPD (Sulistyowati, 2019). This indicates that STEM is a whole unit that correlates with each other to be able to practice students' critical thinking skills. This LKPD can train students' critical thinking skills because students are invited to reflective thinking and involve cognitive processes in analyzing or evaluating something (Khairunnisa, 2021). Strengthened in the research fadlina et al., (2021) and Pramuji et al., (2018) explained that STEM-based LKPD can improve critical thinking skills. In addition, STEM learning trains students to solve problems and improves students' understanding of specific concepts (Zulfawati & Mayasari, 2021).

The practicality test of teachers and students is assessed in three aspects, namely the content aspect, the presentation aspect, and the linguistic aspect. The student practicality test was carried out to determine student responses as research subjects to STEM-based LKPD products (Safitri, 2020). Here are the results of the practicality test of teachers and students.

Chart 3. Teacher and Student Practicality Test Results

Based on the chart above, the STEM-based LKPD that has been developed meets the criteria so that students can easily use it. Practicality itself according to Agnezi (2019) shows the level of ease in the implementation, use, and process of carrying out certain activities in a product developed.

The content aspect earned a percentage of 82% by teachers and 87% by students with very practical categories. In this case, the description of the content of each LKPD already leads to STEM aspects, the use of LKPD makes students actively study, and the material is presented in a sequence and clear manner. On the aspect of the presentation, the teacher obtained a percentage of 84% and 86% by students with a very practical category. In this case, the overall contents of the LKPD, both illustrations, drawings, and tables are arranged. In terms of appearance, the design and color are presented quite attractive, and the selection of font sizes is quite clearly legible. Then, a language spec gained a percentage of 84% by teachers and 88% by students with a very practical category. The language used is easy to understand, simple and complies with PUEBI. In addition, the use of interactive and communicative language makes it easier for students to understand the content of the LKPD so that students do not have to ask the teacher much (Simatupang et al., 2019).

**CONCLUSION**

Based on the results of research and discussion, it can be concluded that (a) This research produces STEM-based LKPD (Science, Technology, Engineering, and Mathematics) on the theme of my home electrical circuit that can improve students' critical thinking skills and is declared valid or suitable for use with an average percentage of 80.9%.

(b) STEM-based LKPD (Science, Technology, Engineering, and Mathematics) is stated to be very practical to use based on the average results of teacher practicality tests of 83% and students of 87%. (c) Furthermore, STEM-based LKPD (Science, Technology, Engineering, and Mathematics) was declared effective in improving students' critical thinking skills based on the results of the N-Gain calculation of 0.68 with a moderate category and an effect size result of 2.7 with high criteria.

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