

The Effectiveness of STEM-Based Android-Based Learning Media on Students' Critical Thinking Skills

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Abstract

PISA data shows that the critical thinking skills of 21st century students are still at a low level. The 21st century requires students to be able to integrate technology in learning activities. Android-based learning media is an alternative learning media that is integrated with technology. Science, Technology, Engineering, and Mathematics (STEM) is an integrative approach that can improve critical thinking skills. This study aims to analyze the effectiveness of Android-based learning media with the STEM approach to improve students' critical thinking skills. The study used Research and Development (R&D) method, namely introduction, media validation, and media testing. The subject of this research is class X vocational school majoring in motorcycle engineering and business. Data collection techniques used research instruments with quantitative data analysis. The data collection instrument was given through a written test in the form of essay questions that included aspects of critical thinking skills. The results of this study indicate that the results of the n-gain mean the pretest and posttest values was 0.77 with high criteria. Aspects of critical thinking skills that make a major contribution were aspects of evaluation and conclusion. Based on the results of the study, it can be concluded that Android-based learning media with the STEM approach is effective in improving creative thinking skills.

INTRODUCTION

The development of technology and information has an impact on all areas of life, including education. Success in facing the 21st century is determined by the quality of the learning provided by the teacher (Lase, 2019). Qualified students are able to compete globally and master technological developments (Subekti *et al.*, 2018). The 21st century demands that today's learning be able to utilize technology and information. Learning in the 21st century focuses on using technology to meet future needs (Singgih *et al.*, 2020). Covid-19 requires the education system to conduct distance learning. Learning activities are carried out online by utilizing learning media that is integrated with technology. This condition causes the involvement of students in achieving 21st century competencies has not been fully optimized, so that it has an impact on significantly untrained critical thinking skills. Students have skills in operating cellphones well. This means that there is an opportunity to take advantage of Android-based mobile as a media and learning resources that can be used by students. The results of the literature study from Girwidz *et al.* (2019) states that the percentage of mobile, smartphone, and tablet use in learning has increased significantly from year to year.

The media available at Al Hikmah Islamic Vocational School 2 has not been integrated with technology such as Android-based learning media. The learning media also has not presented contextual materials related to science, technology, engineering, and mathematics and has implications for aspects of critical thinking skills. The 21st century learning skills can be improved through an integrative approach that is able to link several sciences with their application in daily life, one of which is the Science, Technology, Engineering, and Mathematics (STEM) approach (Erdogan & Ciftci, 2017). The STEM approach is still rarely applied at the vocational school level. The STEM approach is an approach that is suitable for use in vocational school.

Physics lessons in vocational school are required to be able to convey material that can train students' soft skills. Learning activities need to train students' critical thinking and creative thinking skills. Learning media based on Android direct current electricity is needed in vocational school as a more flexible medium and can be used by students anywhere and anytime. Android-based learning media is able to combine components of text, images, and videos that are more interactive so that it is expected to be able to develop students' thinking skills. Android-based media direct current electricity in vocational school is effectively used in learning activities and has an influence on student learning outcomes (Taufik & Kristanto, 2018).

Learning media with the Android system is one of the most popular media in the 21st century and is an example of technology-integrated media. Based on the review conducted by Irfana *et al.* (2021) the media in the form of Android applications is necessary and essential to be implemented and developed. Learning media in the 21st century does not only involve technology, but students must also be able to use technology as a learning resource. Learning media with the Android system is very important for students in preparing students to keep up with the times and develop 21st century learning skills (Ashim *et al.*, 2019). Technology in the form of an Android smartphone is an alternative media development that can be easily used by students in learning. This media has the advantage that it can be used as a learning resource for students and is more flexible (Bano *et al.*, 2018 and Hendikawati *et al.*, 2019). Based on the existing problems, it is necessary to know the effectiveness of Android-based learning media with a STEM approach to improve 21st century learning skills, especially critical thinking skills.

METHOD

This study uses the research and development (R&D) method adopted from Sugiyono (2015). The research steps include potential and problems, data collection, product design, design revision, design validation, design revision, limited-scale product test, product revision, large-scale product test, and analysis of product test results. The subjects in this study were students of automotive class XI-4 for the limited scale test and class X TBSM 4 for the large scale test. The research was conducted from July to August 2021. The data collection technique used instrument research with quantitative data analysis. The data collection instrument used a written test in the form of an essay. Critical thinking skills in this study were measured to provide essay questions that have been tested and analyzed to meet the criteria of validity, reliability, distinguishing power.

Critical thinking aspects in this study according to Binkley *et al.* (2012), namely aspects of analyzing, evaluating, explaining, concluding, interpretation, inference, and synthesis. At the beginning of learning, a pretest was conducted to measure students' critical thinking skills before learning using STEM-integrated Android-based learning media. The material in the media is about the identification of direct current electricity, direct current electricity sources, series and parallel electric circuits, Ohm's law, and the application of technology regarding direct current electricity such as flashlights and electric motorcycles. After the pretest was done, learning was carried out using STEM-integrated Android-based learning media, then at the end of the learning, a posttest was carried out. Analysis of critical thinking skills improvement

was carried out by using the N-gain test of pretest and posttest scores.

RESULTS AND DISCUSSION

Improvement of critical thinking skills is assessed through a written test in the form of essay questions. The mean values of the pretest and posttest are presented in Table 1. Learning media

based on Android STEM integration was developed to support the development of 21st century thinking skills, namely critical thinking skills. The results showed that the developed media was able to improve critical thinking skills. These results are in accordance with the research of Davidi *et al.* (2021), Sukmana (2018), Onsee & Nuangchalerm (2019), and Debora & Pramono (2022) which show that integrating the STEM approach in learning activities effectively improves critical thinking skills.

Table 1. Average Value of Critical Thinking Pretest and Posttest

Class	Average Pretest	Average Posttest	Results	N-gain Upgrade Criteria
X TBSM 4	49.57	88.21	0.77	High

Based on Table 1, there was an increase between the average pretest and posttest scores. The results of the analysis of the pretest and posttest

values of each aspect of critical thinking are presented in Figure 1.

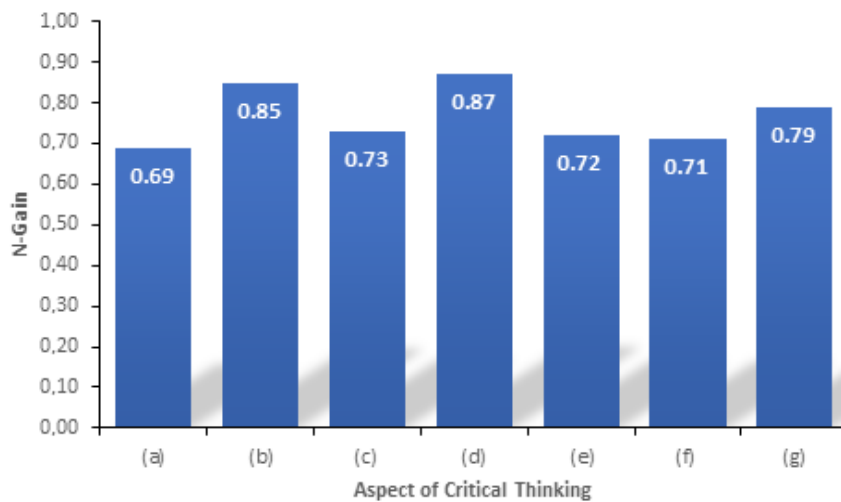


Figure 1. Analysis of N-gain Test Results for Critical Thinking

(a) Analyze (b) Evaluation (c) Explain (d) Concluding (e) Interpretation (f) Inference (g) Synthesis

Based on Figure 1, the results of the analysis using N-gain show that there is an increase in the average pretest and posttest scores on critical thinking skills. The discussion as follows.

1. Analyze

There was an increase in critical thinking skills, where the average value of the pretest and posttest was increase from 49.57 to 88.21 with high improvement criteria, as shown in Table 1. Aspects of analyzing lies in the ability of students to analyze and identify information or concepts that have been studied. Factors that influence the aspect of analyzing are identifying concepts and answering statements presented with concepts and accompanied by examples of contextual application of technology. Pertiwi (2018) stated that providing material by identifying concepts can improve critical

thinking skills. In this study, learning activities using Android-based learning media with a STEM approach have been running well. This is supported by the average value of the pretest and posttest which has increased by 0.69 with moderate criteria, as shown in Figure 1.

2. Evaluation

The evaluation aspect is the ability of students to evaluate and express important things or express weaknesses in the information that has been studied. Starting from identifying information, students were asked to evaluate direct current electric circuits, which were combined (series-parallel) circuits. The factor that influences the evaluation aspect was the students' accuracy in expressing their opinions regarding series-parallel series drawings. This is in accordance with the research of Benjamin *et al.*

(2021) which stated that accuracy determines the resolution of a problem. Efforts to improve critical thinking skills using Android-based learning media with a STEM approach in learning activities were able to improve aspects of student evaluation. Efforts to improve critical thinking skills using Android-based learning media with a STEM approach in learning activities can improve the evaluation aspects of students. This is indicated by the average value of the pretest and posttest which has increased by 0.85 with high criteria.

3. Explain

Students were asked to explain the disadvantages of series and parallel circuits. Most of the students were able to explain the weakness of the electric circuit. This is indicated by an increase in the average value of the pretest and posttest. The average value of the pretest on the explaining aspect is 48.44 and the average value of the posttest is 85.94 with the criteria for high improvement. The explaining aspect is assessed based on students' skills in expressing opinions using the results of reasoning in accordance with the context of the problem. This ability is able to give reasoning to students about the case of electric circuits. Benjamin *et al.* (2021) mentions that in the explanation aspect a person is able to present in a convincing and coherent way the results of reasoning. Based on this, it can be concluded that learning using Android-based learning media with a STEM approach in this study is able to improve aspects of explaining.

4. Concluding

The results of the study presented in Figure 1 show that students' critical thinking skills have increased in the aspect of concluding. Students are asked to make conclusions related to the concept of series and parallel circuits, in solving these problems most students are able to conclude about series and parallel circuits. The aspect of concluding in this study is based on students' skills in giving conclusions in accordance with the relevance of the opinions given regarding the material. Critical thinking skills have increased, marked by aspects of concluding which have increased with high criteria. The increase was due to the "Let's Discuss" and "Time to Action" features train students in drawing conclusions from the discussion activities carried out. This is in accordance with the results of research by Benjamin *et al.* (2021) which states that the higher the critical thinking ability, the higher the ability to conclude. The improvement of students' critical thinking in learning using Android-based learning media with the STEM approach in this study was able to improve the concluding aspect as indicated by the average pretest and posttest scores of 0.87 with high criteria.

5. Interpretation

In the learning process, students are able to understand series and parallel circuits, the concept of direct current electricity and its application in motorcycle technology such as horn systems, turn signal systems, and starter motors that use the concept of direct current electricity. Students also understand the relationship between electric current, potential difference, and resistance contained in the media through graphs. The improvement of critical thinking skills in the interpretation aspect obtained an average pretest value of 46.88 then after learning activities using Android-based learning media with the STEM approach increased to 85.16 with high improvement criteria. The results showed that there was an increase in the interpretation aspect, which was 0.72 with high criteria. The interpretation aspect in this study was assessed based on the students' ability to interpret the meaning or explain the reasons for a concept. In learning activities, students are asked to interpret the meaning of Ohm's law equation. Most students are able to explain the meaning of Ohm's law equation. Research by Susilowati *et al.* (2017) mentions that incomplete and inaccurate interpretation skills affect critical thinking skills in solving problems. This is supported by Pertiwi's research (2018), that students who are able to interpret or understand problems well have good critical thinking skills. Improved aspects of interpretation using Android-based learning media with a STEM approach in this study were able to improve critical thinking skills. The increase in the interpretation aspect of the pretest and posttest got 0.72 with high criteria.

6. Inference

In Figure 1, students' critical thinking skills in the inference aspect increase. Most students are able to draw electrical circuits well. This is indicated by the average value which has increased from the pretest of 51.56 to 85.94. Media includes material and discussion activities that ask students to make conclusions or descriptions of direct current electric material. The inference aspect in this study was assessed based on the students' ability to make conclusions or predictions based on the patterns contained in the concept. Learning activities using the media went well, which was indicated by the average student having exceeded the KKM score. Research by Susilowati *et al.* (2017) stated that inference ability affects students' critical thinking skills. Efforts to improve critical thinking in this study succeeded in increasing the inference aspect as indicated by the increase in the average pretest and posttest scores of 0.71 with high criteria.

7. Synthesis

Aspects of synthesis contained in the media include conclusions about resistance in series and parallel, conclusions about batteries in series and parallel, as well as opinions about power sources in electric motorcycles. In this study, students were able to solve the problems contained in the discussion sheet by answering questions. Based on Figure 1, it is known that there was an increase in the synthesis aspect of 0.79 with high criteria. The ability of students assessed from the synthesis aspect is the ability of students to make arguments by combining information that is not explicitly stated in the material. Puspawati *et al.* (2014) states that synthesis skills are skills in combining information into a new argument. The synthesis aspect in Android-based learning media with a STEM approach can be seen in the discussion activities contained in the "Let's Discuss" and "Time for Action" features. In learning activities, after getting material on series, parallel, and combined electric circuits, students are asked to design vehicle lights based on the direct current electricity they have learned. The synthesis aspect affects the level of students' critical thinking skills. Students who are unable to perform analysis, synthesis, and evaluation have critical thinking skills that are not well developed (Purwana & Saputra, 2019).

After learning activities using the media, students' critical thinking skills have increased. Aspects of critical thinking are integrated into Android-based learning media through the features of "STEM", "Let's Discuss", and "Assessment". Aspects of critical thinking in the media in the form of material, discussion activities, and questions. The material in the media is direct current electric material equipped with pictures and videos. The media presents examples of the application of direct current electricity in simple technology, namely motorbikes and flashlights. Discussion activities that involve students improve student understanding, so that students are able to solve discussion problems well. Based on the results of the study, it can be concluded that the Android-based learning media with the STEM approach is able to improve aspects of critical thinking skills. This is in accordance with the results of Putri *et al.* (2020), that improving students' critical thinking skills through STEM learning has a high significance test result.

CONCLUSION

Based on the results of the study, it was concluded that Android-based learning media with a STEM approach could improve students' critical thinking skills, indicated by the N-gain test of 0.77 with high criteria. The aspect that has a big influence on critical thinking skills is the aspect of evaluation and conclusion. Android-based learning media with

a STEM approach is effective in improving students' critical thinking skills

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