Vol. 14, No. 03, pp. 2176-2190, 2024 DOI: 10.23960/jpp.v14.i3.2024147

Jurnal Pendidikan Progresif

e-ISSN: 2550-1313 | p-ISSN: 2087-9849
http://jurnal.fkip.unila.ac.id/index.php/jpp/

Integrating Creative Problem-Solving in Electronic Teaching Materials to Enhance Problem-Solving Skills of High School Science Students

Andi Ichsan Mahardika*, Muhammad Arifuddin, & Nana Sophia Lazuardi
Department of Mathematics and Science Education, Universitas Lambung Mangkurat, Indonesia

*Corresponding email: ichsan_pfis@ulm.ac.id

Received: 09 December 2024 Accepted: 31 December 2024 Published: 06 January 2025

Abstract: Integrating Creative Problem-Solving in Electronic Teaching Materials to Enhance Problem-Solving Skills of High School Science Students. Objectives: The problem-solving ability of SMA Negeri 1 Amuntai students is still in the low category due to the unavailability of teaching materials that contain problem-solving skills. This research aims to produce electronic teaching materials using creative problem solving models on particle dynamics topics that are feasible to improve students' problem-solving skills. The specific purpose of this research is to describe the validity, practicality, and effectiveness of the electronic teaching materials developed. **Methods:** The research method used is a research and development method using the ADDIE model. The test subjects were 19 students of class X MIPA 1 SMAN 1 Amuntai. The research design used is one group pretest posttest. The data collection technique uses validity assessment instruments, questionnaires for the response of students and pretest-posttest learning outcome tests. **Findings:** The results showed: (1) electronic teaching materials are valid because their validity is 3.30 with valid categories, (2) teaching materials are practical because the response of students is 2.83 with practical categories, (3) electronic teaching materials are included as effective because the average n-gain score of 0.32 is in the effective category. **Conclusion:** Thus, electronic teaching materials using creative problem solving models on the topic of particle dynamics are worthy of use to improve students' problem-solving skills.

Keywords: creative problem solving, electronic teaching materials, problem solving skills.

To cite this article:

Mahardika, A. I., Arifuddin, M., & Lazuardi, N. S. (2024). Integrating Creative Problem-Solving in Electronic Teaching Materials to Enhance Problem-Solving Skills of High School Science Students. *Jurnal Pendidikan Progresif*, *14*(3), 2176-2190. doi: 10.23960/jpp.v14.i3.2024147.

INTRODUCTION

Digital competence has become increasingly important in modern education, especially amid rapid technological advancements. The ability to effectively use digital tools not only supports the teaching and learning process but is also closely related to problem-solving skills. Research by Blyznyuk (2018) indicates that digital competence encompasses several essential aspects, including the ability to search for and manage information, communicate effectively, and create relevant educational content. Blyznyuk emphasizes that problem-solving skills are an integral part of digital competence, where educators must be able to identify and address various technical challenges that arise during the learning process. Thus, developing digital competence not only prepares students for future academic and professional challenges but also strengthens their ability to face and resolve problems encountered in everyday life.

Muhamad *et al*. (2019) mentioned that there are several skills or skills that students must have in facing the era of the industrial revolution 4.0, including critical thinking and expertise in problem solving. Problem solving is an ability that is needed to find solutions to the problems he faces based on the knowledge he already has. Because of this, problem-solving skills must be possessed by students, especially after learning concepts such as physics, because physics has a significant role in the development of science and technology. Advanced educational technology can be defined as a combination of processes and tools involved in addressing educational needs by using the latest and advanced tools such as computers and other electronic devices (Shadiev *et al*., 2022). Answering the challenges of education in the future is inseparable from technological developments. However, the role of teachers is still needed, and must be able to present innovative and creative learning so that students will constantly be challenged to do learning according to their needs. The assessment system has also become an electronic assessment. In the 21st century, the electronic evaluation system has become a requirement in higher education. The electronic evaluation overcomes the constraints of traditional assessment with numerous advantages (Elfirdoussi et al, 2020).

When facing a problem and looking for a solution to solve a problem, students are expected to first understand the problem at hand. Good understanding is intended so that students can solve a complex problem based on the expertise of understanding and analyzing information. A complete understanding can be a good provision for students in solving a problem (Kue *et al*., 2019). Students in learning activities are expected to be able to interact actively with each other, have the expertise to communicate, find solutions to problems, and apply learning outcomes to daily life. The benefits that can be obtained by students from problem solving include that students can learn more actively in learning activities (Dixit et al, 2021). The selection of methods in learning that are not appropriate has an effect on the low level of analytical ability of students in overcoming a physics problem (Wider *et al*., 2023). Sappaile et al (2024) said that in the learning process, students need interesting and easy-to-understand teaching materials so that the solutions obtained can easily solve problems related to learning materials. Problem solving is a fairly complicated thought process that requires basic thinking skills to recognize problems and choose the right solution.

Creative problem solving or abbreviated as CPS is a learning model that applies concentration to teaching and problem solving skills accompanied by strengthening skills. The process of the CPS learning model is divided into 4 stages of learning, namely problem clarification, brainstorming / expressing opinions, evaluation and selection, and implementation. The CPS learning steps proposed can familiarize students to communicate their mathematical thinking, think critically to find solutions to solve a problem they encounter, think systematically and make sense according to existing facts/ data and can accustom students to communicate and interact with each other. The creative problem solving model is included in the active learning model. In terms of active learning, learning is not only focused on the delivery of the teacher, but rather the learners who have the responsibility to learn. As a practical and creative methodology, active learning puts learners at the center of the learning experience to increase motivation. Active learning brings students and teachers closer to the core of the learning process where teachers share learning experiences with students so that interactions occur that make teachers and students closer, thus making the learning process richer and more meaningful. Learners are not only passive agents in learning, because learning is not just a matter of listening in class, taking notes, and occasionally asking questions to the teacher, but above all it is participation and commitment in learning so that the planned learning goals can be achieved. Therefore, the teacher himself is required to adopt a new approach in teaching in the classroom, as well as a new role in guiding and facilitating the learning process (Olmedo-Torre *et al*., 2021).

Ramadhanti *et al* (2020) found that the problem-solving ability of students of class XI MIPA 2 MAN 3 Banjarmasin was in the category of lacking. The results of this study are also in line with the initial study conducted by Izzati *et al* (2020) showing that the problem-solving skills of students at SMAN 5 Banjarmasin are still relatively low. This problem was also strengthened by the results of an initial study conducted by researchers on September 27, 2021 at SMA Negeri 1 Amuntai which showed the low problem-solving skills of students. The percentage for each stage of problem solving is 3.7% of students able to describe physics problems, 40.7% of students are able to describe problems, 3.7% of students are able to plan solutions to problems, 3.7% of students are able to carry out solutions from planning and 0% of students are able to evaluate / re-examine solutions that have been implemented.

The low problem-solving skills among physics students at SMA Negeri 1 Amuntai can be linked to the use of ineffective teaching materials. Many textbooks used in schools only provide material explanations, sample problems, and exercises without integrating the application of necessary problem-solving skills in the context of physics learning. Modern educational theory emphasizes that problem-solving skills are a key element in science education, which must be developed through active and interactive teaching methods. Recent research indicates that the Problem-Based Learning (PBL) model can enhance students' problem-solving skills. According to Celik et al. (2011), the implementation of PBL in physics education not only improves students' analytical abilities but also encourages them to actively engage in the learning process through the resolution of real-world problems.

Research by Elmoazen et al (2023) indicates that the use of virtual laboratories also contributes to the enhancement of students' problem-solving skills, with an average skill percentage reaching 71.06%. However, there is literature suggesting that many current physics curricula still fall short in providing adequate learning experiences to develop these skills. Students often struggle to understand the material due to monotonous teaching methods and a lack of engaging visualizations. Research by Naz et al (2017) reveals that students require more innovative teaching methods and easily comprehensible learning media that are well accessible. Therefore, it is essential to develop teaching materials that are not only informative but also encourage students to actively participate in the problem-solving process. The integration of interactive learning models and the use of visual media can significantly help improve students' problem-solving skills.

Students are expected to be able to understand to solve problems, become skilled in choosing and recognizing conditions and using appropriate concepts, find solutions to problems, make problem solving steps, and organize skills that they have previously possessed. The indicators of problem-solving ability expressed by Heller et al. (1992) consist of 5 stages, namely describing problems, describing problems in physics concepts and principles, planning solutions, implementing plans, and checking and evaluating. The five indicators that affect problem-solving skills in physics include 1) visualization/ description of the problem; 2) the approach of physics; 3) special application of physics concepts; 4) mathematical procedures; and 5) logical conclusions. Low problem-solving skills can be overcome by one solution, namely by developing appropriate and interesting teaching materials, besides that to improve problem-solving skills that are still low is to use appropriate learning models. It has become the goal of every education system to develop individuals who have the ability to think and process knowledge gained from the teaching and learning process. These ideas and knowledge learned must be efficiently applied in society. Strategies must then be carefully selected to suit the needs, interests, motivations, and characteristics of the learners. A good teacher approach to teaching and learning contributes more likely to higher quality learning outcomes. Therefore, it is important for teachers to be careful in choosing the right tools and strategies in delivering their lessons (Valdez & Bungihan, 2019). The results were obtained that the creative problem solving learning model has an influence on increasing students' problem-solving ability.

Based on the background above, this study aims to produce electronic teaching materials using creative problem solving models on the topic of particle dynamics that are valid, practical and effective so that they are suitable for use to improve students' problem-solving skills.

■ METHOD

This research employs a research and development method, known as Research & Development (R&D), utilizing the ADDIE development model, which consists of five steps: Analysis, Design, Development, Implementation, and Evaluation. In the analysis stage, the needs of students and teachers are gathered through interviews with physics teachers to understand the challenges in learning and the necessary materials. Additionally, surveys are conducted with students to identify difficulties in understanding physics material and their preferences for learning media. The results of this analysis provide a clear foundation for designing electronic teaching materials that meet these needs.

After the analysis, the learning program is designed by selecting teaching methods and developing materials and learning activities. The learning materials are then developed based on the established design, including modules and other media. This program is implemented in a real learning environment, involving facilitator training and classroom management. Finally, an evaluation is conducted to measure the effectiveness of the learning program through student learning outcomes and feedback from teachers. By systematically following the ADDIE model, this research aims to produce effective electronic teaching materials that enhance students' problem-solving skills in science. The development stages use the ADDIE model as shown in the following figure 1.

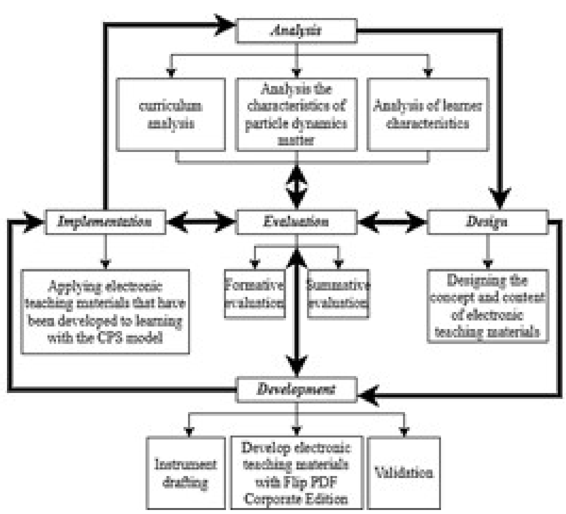

Figure 1. ADDIE development model

This research took place in February-March 2022 at SMA Negeri 1 Amuntai. The trial of electronic teaching materials that have been developed is used by researchers and students in the learning process as many as four meetings with a time division of 3 x 30 minutes at each meeting. The trial design in this study is to compare the situation before and after using electronic teaching materials, in the form of a one-group pretest-posttest design. Formative evaluation is carried out at the design and development stage which is used for the refinement of the developed teaching material. Meanwhile, a summative evaluation is carried out to determine the feasibility of the electronic teaching material produced based on the validity of the teaching material, the practicality of the teaching material, and the effectiveness of the teaching material as well as the achievement of the purpose of the electronic teaching material to improve problem-solving skills.

The research subject is an electronic teaching material using a creative problem solving model on the topic of Particle Dynamics to improve problem solving skills. The test subjects were students from SMA Negeri 1 Amuntai class X MIPA 1, totaling 19 people. The object of this study is the feasibility of electronic teaching materials using creative problem solving models on the topic of particle dynamics to improve students' problem-solving skills in terms of validity aspects, practicality aspects and effectiveness aspects. Validation of electronic teaching materials is carried out by two academics and a practitioner.

Participants

The population in this study consists of tenth-grade students at SMA Negeri 1 Amuntai, which includes various majors. The sample used in this research is students from class X MIPA 1, totaling 19 individuals. The sampling technique employed is purposive sampling, where the researcher selects students based on specific criteria relevant to the research objectives, which is to test the effectiveness of electronic teaching materials that utilize a creative problem-solving model. The selection of class X MIPA 1 is made because the students in this class are considered to have an appropriate academic background and can provide the necessary information to evaluate the improvement of problem-solving skills after using the developed teaching materials.

Research Design and Procedures

The research design used in this study is the One-Group Pretest-Posttest Design. This study was conducted at SMA Negeri 1 Amuntai during February-March 2022. The research procedure begins with the following steps including initial data collection, implementation og treatment, posttest execution and evaluation of results. First initial data collection**,** Before the treatment, a pretest is conducted to measure students' problem-solving skills. This pretest aims to obtain baseline data regarding students' abilities before using the electronic teaching materials. Second procedure is implementation of treatment**.** After the pretest, the developed electronic teaching materials are applied in the learning process over four sessions, each lasting 3´30 minutes. Next procedure is posttest execution**,** the treatment is completed, a posttest is administered to measure the improvement in students' problem-solving skills after using the electronic teaching materials. The last procedure is evaluation of results**.** The data from the pretest and posttest are compared to determine the effectiveness of the teaching materials used in enhancing students' problem-solving skills.

Instrument

In this study, several instruments were used to collect the necessary data, including teaching material validation sheet, student response questionnaire and learning outcome test. Teaching material validation test was developed by the researcher to assess the quality of the electronic teaching materials that have been created. The validation sheet consists of 70 criteria covering aspects of software engineering, content, and benefits. The validity of this instrument was evaluated by two academics and one practitioner. Student response questionnaire is designed to assess the practicality of the developed electronic teaching materials. It includes aspects of attention, relevance, confidence, and student satisfaction with the material being taught. And learning outcome test consists of essay questions designed to measure the effectiveness of the teaching materials in enhancing students' problem-solving skills. The questions were formulated based on problem-solving skill indicators developed by Heller.

Data Analysis

In this study, data analysis was performed to evaluate the validity, practicability, and effectiveness of the developed electronic teaching materials. The developed instructional materials were validated by three experts in the field of physics education using a validation sheet. The resulting data were calculated, and the averages for each aspect were adjusted according to Widoyoko (2019) assessment criteria.

The criteria for the validation aspect of electronic teaching materials based on (Widoyoko, 2019) are if the average value of the validation sheet is more than 3.4 to obtain a very valid category. If the average value of the validation sheet is at an interval of more than 2.8 and less than or equal to 3.4, then a valid category is obtained. If the average value of the validation sheet is greater than 2.2 and less than or equal to 2.8, the category is quite valid. If the average value of the validation sheet is more than 1.6 and less than or equal to 2.22, it gets the less valid category, and if the average value of the validation sheet is less than or equal to 1.6, then it gets the very less valid category.

The practicality of the teaching material is reviewed from the response questionnaire filled out by students. Practicality assessment is obtained from calculating the average score of the response questionnaire results. Then, the calculation results are adjusted to the criteria for the practicality of teaching materials adapted from Widoyoko (2019).

The criteria for the practicality of teaching materials based on student questionnaire responses are in five categories, namely if the average score obtained is more than 3.4, then it is included in the very practical category. If the average score obtained is in an interval of more than 2.8 and less than or equal to 3.4 then it is in the practical category. If the average score obtained is in an interval of more than 2.2 and less than or equal to 2.8, then it is quite practical. If the average score obtained is in an interval of more than 1.6 and less than or equal to 2.2, it is included in the less practical category and if the average score is less than or equal to 1.6, it is included in the impractical category.

The reliability of the validation results is calculated using the Alpha Crombach equation and then the results obtained are adjusted to the reliability assessment criteria table adapted from Siswaningsih et al. (2017). The reliability assessment criteria using Alpha crombach are if the á value is more than or equal to 0.90 it gets the very good category, if the á value is more than or equal to 0.80 and less than 0.90 it gets the good category. If the á value is greater than or equal to 0.70 and less than 0.80, it receives the category of be accepted. If the á value is greater than or equal to 0.60 and less than 0.70 is given the doubtful category, if the á value is greater than or equal to 1.50 and less than 0.60 is obtained the bad category and if the á value is less than 0.50 it is obtained the unacceptable category

Effectiveness is seen from the learning outcomes test data which is then calculated using an n-gain score and the calculation results are adjusted to the Hake (1998). There are several N-gain categories, including if the average value of N-gain is more than or equal to 0.7 obtaining the high or very effective category, if the average value of N-gain is more than or equal to 0.3 and less than 0.7 obtaining the medium or effective category and if the average value of N-gain is less than 0.3 obtaining the low or less effective.

Problem solving skills are reviewed through pretest and posttest questions, with achievement scores assessed according to established guidelines for scoring problem solving skills. If the student's average grade is more than 80 then the problem-solving skills are in the very good category. If the student's average score is more than 60 and less than or equal to 80, it is in the good category. If the student's average score is more than 40 and less than or equal to 60 is included in the category of good enough. If the student's average score is more than 20 and less than or equal to 40 is included in the category of unfavorable, and if the student's average score is less than or equal to 20 is included in the category of unfavorable.

RESULT AND DISCUSSION

Analyze

In the analysis step, this research indicates that the development of electronic teaching materials was conducted with consideration of the revised 2013 curriculum and the needs of students in secondary schools. Data from the pretest show that students' problem-solving skills are at a low level. Most students only note variables without describing the problems in depth, indicating a lack of understanding of particle dynamics material. This aligns with the findings of Tensin et al. (2022), which state that students often struggle to interpret complex physics concepts due to the abstract nature of the material, and suggest that better understanding can be achieved through improved instructional strategies.

Research by Pfannenstiel et al (2015) explains that students tend to rely solely on the formulas that have been taught, so when faced with modified problems, they struggle to solve them. Therefore, the results of this study indicate an urgent need to design teaching materials that not only present information but also engage students in active learning processes.

Design

In the design phase, this research produced electronic teaching materials that were designed with consideration of aspects such as format, language, content, and presentation. Validation results indicated that all these aspects received a valid category, with the highest average scores in the presentation aspect (3.42) and benefits (3.67). Research by Serevina et al (2018) supports this finding, where well-designed e-modules can enhance students' understanding of the material.

The design of the teaching materials also includes multimedia elements such as images and videos, which have proven effective in helping students understand difficult physics concepts. According to Mardiana et al (2023), the use of animations and videos in e-books can make content more engaging and easier for students to comprehend. This indicates that the design of teaching materials should consider various media to meet students' learning needs.

Development

In the development phase, the electronic teaching materials were produced using Flip PDF Corporate Edition software. Validation showed that the teaching materials met the necessary quality criteria to support learning in secondary schools. The presentation aspect received a very valid rating, reflecting a systematic and engaging presentation of the material. This aligns with research by Kumar et al (2021), which emphasizes the importance of interaction between students and learning content through the appropriate use of educational technology.

Figure 2. The results of the development of electronic teaching materials

Results and Discussion of validation of electronic teaching materials

The electronic teaching materials developed are then validated with the aim of assessing the quality of the electronic teaching materials developed including aspects of format, software engineering, language, content, presentation, and benefits/ usability. The results of the validation of the developed electronic teaching materials are contained in the following table.

Based on the validity test of the developed electronic teaching materials, it obtained a valid category in the aspect of software engineering with an average of 3.07. In the format aspect, the results of the valid category were obtained with an average of 3.30 spectroscopy, in the language aspect obtained a valid category with an average of 3.32 spectroscopy, then in the content aspect obtained a valid category with an average of 3.27 spectroscopy, in addition to the aspect of presentation and benefits obtained a very valid category with an average of 3.42 and 3.67 respectively. Overall, the electronic teaching materials developed based on the validity test obtained an average score of 3.30 with the valid category. Based on the data obtained from the results of the calculation, the reliability coefficient is categorized as very good with a value of 0.97. Based on the results of the validity test, the electronic teaching materials developed are valid and reliable to be used as teaching materials in physics learning in schools.

Electronic teaching materials that have been developed before being used in learning have gone through the validation stage. Validation of electronic teaching materials includes several aspects including software engineering, format (cover, design, typeface, and so on), language (communicative, dialogue, interactive, straightforward, and so on), the content of electronic teaching materials (coverage, accuracy, update), presentation (presentation techniques, presentation support, can be used with creative problem solving models, sample questions and exercises to improve problem solving skills) and aspects of benefits or usability electronic teaching materials. According to Geschwind *et al.* (2024) validity is a test carried out to assess the quality of a product obtained from research and development. There are four aspects of feasibility, namely the feasibility of presentation, graphics, content and language.

Based on the validity test of software obtaining valid categories, thus the development of electronic teaching materials already uses the right software because it does not take up much memory, because the size of the application (software) affects the performance of the application, the application can run smoothly, there are not many bugs and errors in the application, as well as short loading when the application is used. The format aspect with the sum of 10 criteria obtains validity with valid categories. It can be seen that the cover of the developed electronic teaching materials has an appeal. According to Pavlin et al (2019) animation and video in e-books are useful to make it easier for students to understand the content of abstract material. The option of selecting each color element in the layout of this e-book, both fonts, materials, colors, animations, videos, and layout compositions take into account aspects of beauty feasibility and usability in order to make it easier when used as a reading medium. The language aspect consists of 19 criteria for obtaining validation results with valid categories. The criteria for conformity with the development of students' thinking and conformity with the social emotional level of students are appropriate so that the criteria for electronic teaching materials developed in accordance with the development of students are appropriate. Communicative, dialogue, interactive and straightforward criteria acquire valid categories. As well as research conducted by Butt (2020) e-modules at the validation stage received a high category on linguistic aspects which showed that the choice of language used in the e-module was in accordance with language rules, because it could provide explanations or information that were not difficult to understand and did not create confusion or double meaning. The content aspect consists of 11 criteria with valid category validation results. Criteria in the content aspect include the scope of material that contains breadth, depth and problem-solving skills. The presentation aspect contains 24 criteria and obtaining category validation results is very valid. The presentation criteria consist of consistency of the systematics of the presentation in chapters or subsections, the logicality of good presentation, the collapse of the concepts contained, listing the sources in each image or table, facts, concepts, principles and theories that are interconnected. The last aspect, namely the benefits or uses, contains 2 criteria for obtaining very valid category validation results. This electronic teaching material can be used by teachers as a guide in the learning process because the material compiled has been adjusted to the curriculum used in schools, namely the revised 2013 curriculum, and can be used by students for independent learning.

Results and Discussion of the practicality of electronic teaching materials

The practicality of electronic teaching materials is obtained from response questionnaires that are distributed to students after the learning process is complete. The attention aspect (attention) related to electronic teaching materials used during learning can attract the attention of students such as the display of presentation of electronic teaching materials, drafting design, writing style, how to model physics problems, and illustrations or drawings used. Related to the presentation of electronic teaching materials that can attract the attention of students to learn this is because electronic teaching materials not only contain text, but are also equipped with images, video explanations of the material, general information and links that can be accessed so that they can increase students' knowledge. Each example of the problem in this electronic teaching material is equipped with a description of the stages of problem-solving skills so as to attract the attention of students to model physics problems with pictures. In addition to being related to problem solving skills associated with the creative problem solving model, students are given the freedom to model physics problems in accordance with the creativity of the students themselves without being separated from the physics concepts studied. In addition to attracting attention, the electronic teaching materials developed also use the help of technology that students always use, namely cellphones so that students are more motivated to learn. Mobile learning uses mobile devices as a learning tool that serves as an active component for learning and learning through social interaction in the context of the classroom. On the one hand, mobile devices can help learners connect with other learners and other experts in their field, and on the other hand, learners can choose to study within their own personal space while having access to the internet and web resources, such as watching learning videos and using virtual laboratory features (Wilson *et al*., 2020). Advanced educational technology has many advantages such as it can be used to clearly simulate and refine some specific learning activities or extend learning to the outside world, as well as allow interaction with teachers, peers, and learning content learned (Shadiev *et al*., 2022).

The relevance aspect consists of criteria for the use of sentences on electronic teaching materials, the suitability of the content of the teaching material with the interests of students, the content of the electronic teaching material content can be connected to things in everyday life, the preparation of words in electronic teaching materials, the suitability of the content of electronic teaching materials with the needs of students. On the criteria for the suitability of the content of the electronic teaching material with the interests of students, they obtained the lowest score with 7 out of 19 students choosing to disagree, 1 in 19 students chose to strongly agree and 11 out of 19 students chose to agree. Overall the relevance aspect of the category is quite practical. The electronic teaching materials developed still need improvement from several aspects of preparation including in terms of material content in order to better attract students in learning the electronic teaching materials developed and choosing clear and easy-to-understand sentences.

Implementation

In the implementation phase, the electronic teaching materials were tested in the learning process. The results from the student response questionnaire indicated that the average practicality of the teaching materials reached 2.83 and was categorized as practical. Although there are several aspects that need improvement, overall, these teaching materials can still be effectively used in the learning process. Previous research shows that the use of mobile technology in learning can enhance student motivation Aremu (2021). The graph depicting the achievement of problem-solving skills in the pretest and posttest is shown in Figure 3 below.

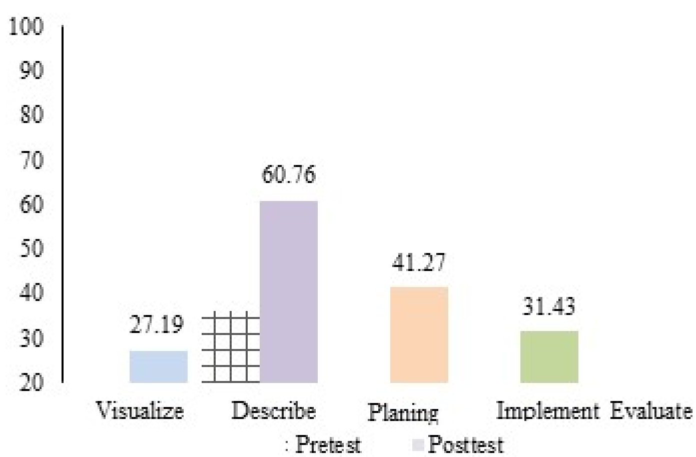

Figure 3. Graph of achievement of learner problem-solving skills

The evaluation of student responses through a questionnaire revealed that the average practicality score of the teaching materials was 2.83, categorizing them as practical. This indicates that the materials were generally well-received by students and could be effectively utilized in the learning process. Despite this positive result, the need for improvement in certain areas was noted. These areas might include: ensuring that the materials are visually appealing and easy to navigate, enhancing the relevance and clarity of the material to better match learning objectives, adding features that encourage active student participation could further improve the materials' practicality.

The findings align with Aremu (2021), who highlighted that the integration of mobile technology in learning environments significantly enhances student motivation. Mobile and electronic technologies offer several advantages, such as: tudents can engage with the materials anytime and anywhere, making learning more flexible. interactive elements in electronic teaching materials often captivate students, increasing their focus and participation. Tailored feedback and adaptive learning pathways can cater to individual student needs.

In this study, the practical categorization of the materials suggests that their integration has the potential to improve not only problem-solving skills but also overall student engagement. While the practicality score is promising, there is always room for enhancement.

The practical rating of the electronic teaching materials underscores their potential for use in real-world classroom settings. However, the following steps could enhance their effectiveness: regularly updating the materials based on student and teacher feedback, offering professional development programs to ensure effective implementation of the materials in diverse learning environments, integration with existing curricula: Aligning the materials with national or institutional standards to maximiz their relevance and usability.

Evaluation

In the evaluation phase, the effectiveness of the electronic teaching materials was measured through pretests and posttests. The results showed a significant increase in students' posttest scores from 9.18 to 38.05, with an average n-gain of 0.32 indicating moderate effectiveness. Although there was improvement at each stage of problem-solving skills, challenges still exist in effectively applying problem-solving methods in online learning environments. The findings of Reddy & Panacharoensawad (2017) also noted students' difficulties in solving physics problems during online learning due to a lack of experience and support from teachers.

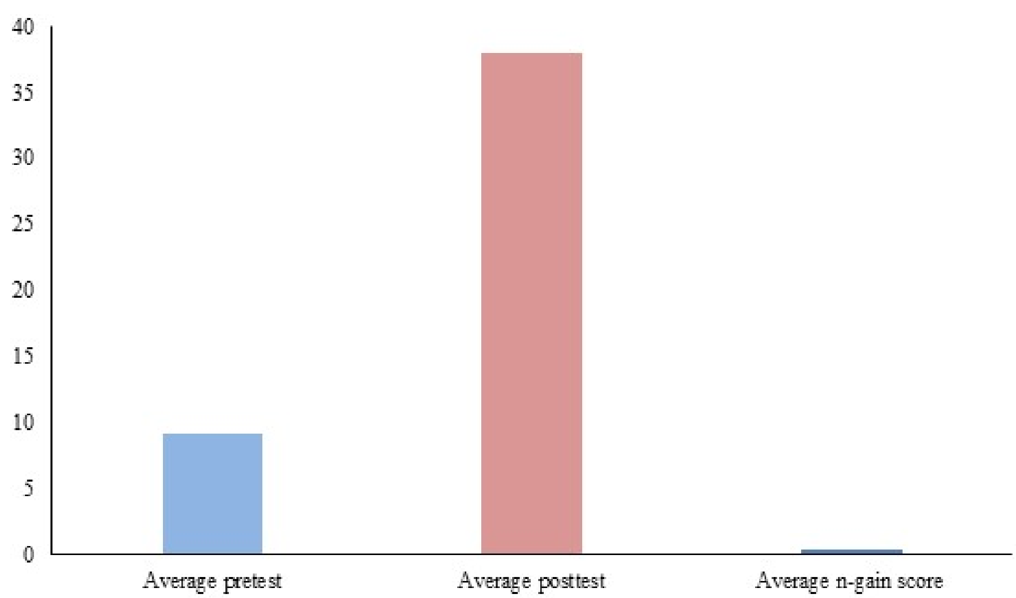

Figure 4. Graph of the calculation of the effectiveness of electronic teaching materials

Overall, the results of this study align with previous literature that emphasizes the importance of developing interactive and technology-based electronic teaching materials to enhance students' problem-solving skills in the context of modern education.

The use of pretests and posttests to measure effectiveness offers robust quantitative evidence. The significant improvement in students' posttest scores, from 9.18 to 38.05, reflects a substantial learning gain. The average n-gain of 0.32 categorizes this improvement as moderately effective. These results indicate that the integration of creative problem-solving approaches into electronic teaching materials can positively impact students' ability to solve problems.

However, while the improvement is encouraging, the moderate effectiveness suggests that there is room for refinement in the teaching materials or their implementation. Possible areas for enhancement include: Incorporating more interactive or adaptive features to further engage students. Providing scaffolding techniques to help students progress through problem-solving stages effectively.

Challenges in Applying Problem-Solving in Online Learning, despite the observed improvements, the study highlights persistent challenges in applying problem-solving methods in online learning environments. These include: limited teacher support: Students may struggle to receive immediate feedback or guidance during online sessions, hindering their ability to develop problem-solving skills independently, lack of experience: Many students are unfamiliar with self-directed problem-solving in an online format, which requires higher levels of autonomy.

These challenges echo the findings of Reddy & Panacharoensawad (2017), who noted that students often face difficulties in solving physics problems in online learning due to inadequate teacher support and their own lack of hands-on experience. This suggests that the problem is not isolated but may be a broader issue within online science education.

Implications for Practice, the findings point to several implications for educators and instructional designers: improving teacher-student interaction, even in online settings, mechanisms like real-time chat or video conferencing can provide the needed support: designing materials with guided problem-solving stages, breaking down problems into manageable steps can help students build confidence and skills incrementally: encouraging collaboration: Online peer discussions or group problem-solving activities could mitigate the lack of teacher support.

■ CONCLUSION

Based on the research findings, the electronic teaching materials developed using a creative problem-solving model on the topic of particle dynamics have proven effective in improving students' problem-solving skills. The validity of these teaching materials was assessed by three validators from various aspects, including software engineering, format, content, language, presentation, and benefits, all of which received average results in the valid category. Additionally, the practicality of the teaching materials measured through student response questionnaires also indicated a practical category. The effectiveness of these materials was measured using learning outcome tests with n-gain score calculations showing results in the moderate category, thus concluding that this electronic teaching material is effective in enhancing students' problem-solving skills.

The impact of this research on education is that the development of electronic teaching materials can serve as an effective alternative to improve students' understanding of physics content, particularly particle dynamics. However, this study also has several limitations. One limitation is that the learning was conducted online, which may reduce direct interaction between students and teachers and hinder deep conceptual understanding. Furthermore, this research focused only on one topic in physics and did not consider other variables such as students' learning styles or social contexts that could influence learning outcomes. Therefore, further research is needed to explore the impact of these factors in the context of physics learning using electronic teaching materials.

REFERENCES

Aremu, B. V. (2021). The use of mobile learning to improve students' motivation and the achievement of learning outcomes. *Kampala Journal of Humanities*, *6*(2), 175-183.

Blyznyuk, T. (2018). Formation of Teachers' Digital Competence: Domestic Challenges and Foreign Experience. *Journal of Vasyl Stefanyk Precarpathian National University*, *5*(1), 40–46. https://doi.org/10.15330/jpnu.5.1.40-46.

Butt, T. M., Shahbaz, B., Hassan, M. Z. Y., & Khan, M. (2020). A critical analysis of e-learning agricultural technical capacity for rural development: lessons from Pakistan. *GeoJournal*, 1-13.

Celik, P., Onder, F., & Silay, I. (2011). The effects of problem-based learning on the students' success in physics course. *Procedia-Social and Behavioral Sciences*, *28*, 656-660.

Dixit, B., Bedekar, M., Jahagirdar, A., & Sathe, N. (2021). Role of active learning techniques in development of problem-solving skills. *Journal of Engineering Education Transformations*, *34*, 670-674.

Elfirdoussi, S., Lachgar, M., Kabaili, H., Rochdi, A., Goujdami, D., & El Firdoussi, L. (2020). Assessing distance learning in higher education during the COVID 19 pandemic. *Education Research International*, *2020*(1), 8890633.

Elmoazen, R., Saqr, M., Khalil, M., & Wasson, B. (2023). Learning analytics in virtual laboratories: a systematic literature review of empirical research. *Smart Learning Environments*, *10*(1), 23.

Geschwind, G., Vignal, M., Caballero, M. D., & Lewandowski, H. J. (2024). Evidence for validity and reliability of a research-based assessment instrument on measurement uncertainty. *Physical Review Physics Education Research*, *20*(2), 020125.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Izzati, A. U., Arifuddin, M., Suyidno, S., & Misbah, M. (2020). Pengembangan perangkat pengajaran langsung untuk melatihkan keterampilan pemecahan masalah peserta didik SMA. *Jurnal Inovasi Dan Pembelajaran Fisika*, *7*(2), 190–199. https://doi.org/10.36706/jipf.v7i2.11160

Kumar, P., Saxena, C., & Baber, H. (2021). Learner-content interaction in e-learning-the moderating role of perceived harm of COVID-19 in assessing the satisfaction of learners. *Smart Learning Environments*, *8*, 1-15.

Kuo, E., Hull, M. M., Elby, A., & Gupta, A. (2019). Mathematical sensemaking as seeking coherence between calculations and concepts: Instruction and assessments for introductory physics. *arXiv preprint arXiv:1903.05596*.

Mardiana, R., Jaya, A., & Theriana, A. (2023). Interactive Animation to Increase The Students'reading Comprehension. *Esteem Journal of English Education Study Programme*, *6*(2), 291-300.

Muhamad, N., Ab Gani, N., Uyob, S., & Saruji, S. C. (2019). Students' Critical Thinking Skills and Awareness of Industry 4.0: A Preliminary Study. *Journal of Human Development and Communication*, *8*, 13-22.

Naz, F., & Murad, H. S. (2017). Innovative Teaching Has a Positive Impact on the Performance of Diverse Students. *Sage Open*, *7*(4).

Olmedo-Torre, N., Martínez, M. M., & Peña, M. (2021). Effectiveness of blended instructional design based on active learning in a graphic engineering course. *Computer Applications in Engineering Education*, *29*(4), 810–837. https://doi.org/10.1002/cae.22338

Pavlin, J., Glažar, S. A., Slapnièar, M., & Devetak, I. (2019). The impact of students' educational background, interest in learning, formal reasoning and visualisation abilities on gas context-based exercises achievements with submicro-animations. *Chemistry Education Research and Practice*, *20*(3), 633-649.

Pfannenstiel, K. H., Bryant, D. P., Bryant, B. R., & Porterfield, J. A. (2015). Cognitive strategy instruction for teaching word problems to primary-level struggling students. *Intervention in school and clinic*, *50*(5), 291-296.

Ramadhanti, R., Mastuang, M., & Mahardika, A. I. (2020). Pengembangan bahan ajar fisika topik elastistas menggunakan model pengajaran langsung untuk melatihkan kemampuan pemecahan masalah peserta didik. *Jurnal Ilmiah Pendidikan Fisika*, *4*(2), 65. https://doi.org/10.20527/jipf.v4i2.2066.

Reddy, M., & Panacharoensawad, B. (2017). Students Problem-Solving Difficulties and Implications in Physics: An Empirical Study on Influencing Factors. *Journal of Education and Practice*, *8*(14), 59-62.

Sappaile, B. I., Vandika, A. Y., Deiniatur, M., Nuridayanti, N., & Arifudin, O. (2024). The Role of Artificial Intelligence in the Development of Digital Era Educational Progress. *Journal of Artificial Intelligence and Development*, *3*(1), 1-8.

Serevina, V., Astra, I., & Sari, I. J. (2018). Development of E-Module Based on Problem Based Learning (PBL) on Heat and Temperature to Improve Student's Science Process Skill. *Turkish Online Journal of Educational Technology-TOJET*, *17*(3), 26-36.

Shadiev, R., Hwang, W. Y., & Ghinea, G. (2022). Guest Editorial: Creative Learning in Authentic Contexts with Advanced Educational Technologies. *Educational Technology and Society*, *25*(2), 76–79.

Siswaningsih, W., Firman, H., Zackiyah, & Khoirunnisa, A. (2017). Development of Two-Tier Diagnostic Test Pictorial-Based for Identifying High School Students Misconceptions on the Mole Concept. *Journal of Physics: Conference Series*, *755*(1). https://doi.org/10.1088/1742-6596/755/1/011001

Tenzin, S., Tendar, P., & Zangmo, N. (2022). Enhancing Students' Understanding of Abstract Concepts in Physics by Integrating ICT in Teaching-Learning Process. *Asian J. Educ. Soc. Stud*, *26*, 68-80.

Valdez, J. E., & Bungihan, M. E. (2019). Problem-based learning approach enhances the problem solving skills in chemistry of high school students. *Journal of Technology and Science Education*, *9*(3), 282–294. https://doi.org/10.3926/JOTSE.631

Wider, C., & Wider, W. (2023). Effects of Metacognitive Skills on Physics Problem-Solving Skills among Form Four Secondary School Students. *Journal of*

Baltic Science Education, *22*(2), 357-369.

Widoyoko, S. (2019). *Evaluasi program pembelajaran*. Pustaka Pelajar.

Wilson, S. B., & Varma-Nelson, P. (2018). Characterization of first-semester organic chemistry peer-led team learning and cyber peer-led team learning students' use and explanation of electron-pushing formalism. *Journal of Chemical Education*, *96*(1), 25-34.