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A Futuristic STEAM-Integrated PBL Model Enhanced by Digital Technology to Foster High School Students' Creative Thinking in Physics Learning

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ABSTRACT

Objective: *This study aims to analyze the profile of the STEAM-integrated PBL model specifically designed to encourage creative thinking in high school students while learning physics.* ***Method:*** *The research method used is a literature study (literature review) conducted by collecting several previous research journals related to the material.* ***Results:*** *The results of this study indicate that using the STEAM-integrated PBL model improves students' creative thinking. In addition, STEAM learning, teachers, or educational institutions will help the progress of the Indonesian education system. Because the application of STEAM learning can prioritize problem-solving-based learning, especially in physics learning related to everyday life.* ***Novelty:*** *The novelty obtained is that STEAM-PBL Integration as an Effective Approach can Increase Student Creativity compared to conventional methods, STEAM-PBL Has a Broad Impact on Critical Thinking and Problem Solving Skills through a challenge-based approach. Then, the role of technology and digital media in strengthening STEAM-PBL learning by increasing concept understanding and student engagement. Moreover, the Importance of contextualization in STEAM-PBL Learning is easier to understand and increases student interest in learning.*

INTRODUCTION

21st-century skills are skills that students must have in the era of Revolution 4.0. As it enters the fourth industrial revolution, having 21st-century skills becomes crucial to meet new demands (Maloy et al., 2016). Education can meet the demands of the 21st century. Education is an endeavor that aims to prepare students to become 21st-century graduates who can use technology easily (Asrizal et al., 2018). Knowledge plays a role in mastering technology and vice versa. In Indonesia, science and technology play an important role in responding to the needs of the 21st century (Redhana, 2019). 21st-century skills are called the 4Cs, namely 1) Critical thinking, 2) Communication, 3) Collaboration, and 4) Creative thinking (Santofani & Rosana, 2016). The increase in digital media and tools presented as approaches or learning models for teachers and students has led to an increase in the use of technology in recent years (Chu, H.-E., Martin & Park, 2019). Reasons such as educational practices focused on Science, Technology, Engineering, Art, and Mathematics (STEAM) (Dolgopolovas & Dagienė, 2021). One way to improve students' creative abilities is by applying treatments that can optimally influence their creativity levels. One treatment that can be applied is the STEAM learning approach, which integrates the fields of Science, Technology, Engineering, Mathematics, and Arts. STEAM is the development of STEM, which collaborates various disciplines, such as science, technology, engineering, and mathematics while adding elements of art to the learning process. Through this

approach, students are expected to develop skills essential to face the challenges of the 21st century (Bicer et al., 2017; Connor et al., n.d.; Conradty & Bogner, 2018; Oner et al., 2016).

Science, Technology, Engineering, Arts, and Mathematics (STEAM) is integrated learning that can improve students' problem-solving skills (Yuliari & Hanim, 2020). STEAM is an integrated approach in science, technology, engineering, arts, and mathematics to develop students' skills and inquiry while learning. STEAM learning is expected to help fully engage students in using and understanding current subject matter. Engage teachers as facilitators and engage students to explore in class and work together to understand thematic concepts. Skills that can be improved by applying the STEAM approach include critical thinking, creative thinking, higher-order thinking, science process skills, problem-solving, and many more (Budiyono et al., 2020). The STEAM approach can be used in physics education so that students can reflect on their learning in school, which initially only focused on educational theory and then into practice with the support of STEAM aspects (Bin Amiruddin et al., 2022). Science, Technology, Engineering, Arts, and Mathematics (STEAM) is integrated learning that can improve students' problem-solving skills (Yuliari & Hanim, 2020). STEAM is an integrated approach in science, technology, engineering, arts, and mathematics to develop students' skills and inquiry while learning. STEAM learning is expected to help fully engage students in using and understanding current subject matter. Engage teachers as facilitators and engage students to explore in class and work together to understand thematic concepts. Skills that can be improved by applying the STEAM approach include critical thinking, creative thinking, higher-order thinking, science process skills, problem-solving, and many more (Budiyono et al., 2020). The STEAM approach can be used in physics education so that students can reflect on their learning in school, which initially only focused on educational theory and then into practice with the support of STEAM aspects (Bin Amiruddin et al., 2022).

Thanks to the demands of the Industrial Revolution 4.0, creative thinking has become one of students' competencies. Creativity means students can propose or give birth to new things as a blend of ideas or innovations with existing things, all different from before. Weak thinking skills of students cause difficulty in solving learning problems; creative thinking can be improved if encouraged through problem-based learning. This is because creative thinking enables systematic investigation of problems, organizing challenges, formulating questions innovatively, and initially designing solutions. Creativity is defined as the ability of students to create or present new things, either in the form of ideas, innovations, or combinations of existing elements, resulting in something different from before (Manobe & Wardani, 2018; Munandar, 2011; Ngalimun & Ariani, 2013). Problems in the learning process often arise due to students' low thinking skills (Mulyasa, 2009). From the above explanation, it is clear that creative thinking is critical in physics learning. By thinking creatively, students can apply the principles in their daily lives.

One of the supporting models of creative thinking is the problem-based learning model. Problem-based learning is when students face complex problems related to learning material. The tasks vary in pictures, videos, diagrams, or other formats, and the teacher guides students in completing the task. One example of learning is problem-based learning, namely Problem-Based Learning (PBL). The PBL model integrated with STEAM is expected to positively contribute to developing creative thinking in high school students' understanding of physics concepts. These expectations include mastery of physics concepts thoroughly, developing critical, collaborative, and creative thinking skills, and applying physics concepts to real-world situations.

Today, many educational institutions face challenges in facilitating adequate physics education at the secondary school level. Students often have difficulty understanding physics concepts and maintaining an interest in the subject. In addition, physics learning often focuses only on teaching traditional concepts without giving students sufficient opportunities to develop creative thinking skills (Masbuthoh, 2010). Facts in the field show that physics is considered the most challenging subject and a scourge for students. Students' ignorance about the usefulness of physics in everyday life causes them to get bored quickly and not interested in physics lessons. The problems in this context are low student motivation, lack of connection between physics concepts and the real world, and limited opportunities for students to develop creative thinking. In addition, the lack of a STEAM approach in physics learning is an obstacle to integrating various disciplines and the resurgence of student interest. The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach is the primary focus in improving the quality of education, especially in high school physical education.

This study aims to examine the profile of a STEAM-integrated PBL model specifically designed to encourage creative thinking in secondary school students while learning physics using a literature review. The model aims to address the identified problems by providing innovative and relevant learning methods and encouraging the development of creative thinking skills through challenging and engaging learning projects. Therefore, this model profile is expected to impact the quality of secondary school physical education positively.

RESEARCH METHOD

The research method used is a literature review (literature review). Literature study is a term used for a particular research methodology or research and development activity undertaken to collect and evaluate research related to a particular topic. The journal is from Google Scholar and is related to the topic used. The literature review collects data or synthesis related to research topics from various sources such as Google Scholar, Scopus, SINTA, and other websites, as well as Google searches, with time intervals from 2020 to 2024. A total of 40 journals and scientific papers were obtained on the search website to be identified. After collecting journals, a screening of related journals will be carried out, and 20 journals will be obtained. Then, the journals will be analyzed

in depth until a conclusion is made. This research method uses activities related to library information collection methods, reading and recording, and managing written materials.

The synthesis process, known as meta-synthesis, is a technique used to integrate data to generate new theories and concepts and achieve a deeper and more comprehensive understanding. In this study, the article analysis method applied was content analysis (Barnard et al., 2022), which has been modified to suit the research objectives (Marin et al., 2018). This modification was carried out through synthesis and replication of three existing methods, where analyses were carried out on various aspects, such as year of publication, type of research, research subjects, research instruments, learning models, efforts developed, research results, and recommendations that appeared in these scientific articles.

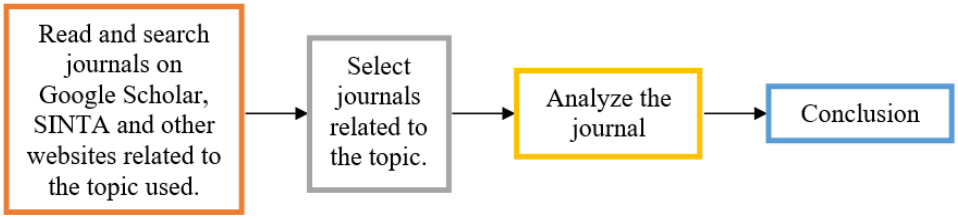

Figure 1. Flow of the research methods used

RESULTS AND DISCUSSION

Results

Based on the results of the analysis that has been done, the Problem-Based Learning (PBL) based learning model is a learning model used by teachers to carry out learning activities. This learning model is carried out with various media as intermediaries, such as using media to explain, practice questions, and conduct experiments to attract attention and increase student interest. In this modern era, there are many learning models that a teacher can use. This study was conducted in group journals related to STEAM-integrated Problem-Based Learning (PBL) to improve students' creative thinking in Table 1.

Table 1. Articles with a focus on the study of STEAM integrated PBL models to improve students' creative thinking.

Title (Researcher, Year published)	Purpose	Method	Result
Designing Comics By Using Problem Based Learning (PBL) to Improve Student's Creative Thinking Skills (Zarvianti, 2020)	The purpose of this study was to determine the development of physics comics for high schools / madrasah aliyah problem-based (PBL) to improve students' creative thinking skills	The research method used is the research and development method, namely the 4D development method which consists of 4 stages, namely defining, designing, developing and disseminating.	The results of the analysis were obtained from the development of physics comics at the SMA / MA level which had valid (0.85), practical (94.67%), and effective criteria which were assessed in the very good category.

Title (Researcher, Year published)	Purpose	Method	Result
	in MAN Sebukar.		And the last stage after the development stage is the dissemination stage, researchers carry out practicality and effectiveness tests in different classes and practical test results are obtained in the very practical category, namely 94.33% of student response questionnaires and effectiveness test results from student knowledge assessments with a percentage of completeness reaching 82.33. % in the very good category, student attitude competence achieved an average score of 87.43% in the very good category, skill competence achieved an average score of 89.17% in the very good category. The design of PBL-based high school / MI physics comics can improve students' creative thinking ability because it ultimately has an impact on students' grades.
Application of Steam Integrated Problem Based Learning to Improve Students' 4c Abilities (Angga, 2022)	The purpose of this study is to improve the 4C skills of these students. A learning model that can improve students' 4C skills to have 4C skills is the Problem Based Learning (PBL) model.	The method used in the research is quantitative method, while the design used is Classroom Action Research (PTK).	The results of the learning implementation show that the application of the STEAM integrated PBL model can improve the 4C ability of grade III elementary school students. Problem Based Learning (PBL) learning syntax is carried out with a percentage of 100%. Posttest results show 90% of students

Title (Researcher, Year published)	Purpose	Method	Result
			achieve scores above KBM. All groups scored above 80. In addition, the student's 4C ability to N-gain results by 0.57 or 57%.
The effect of applying the Steam integrated PBL model on the ability to think creatively is seen from students' understanding of concepts (Budiyono et al, 2020).	This study aims to describe the effect of applying the integrated PBL model of the STEAM approach on the ability to think creatively in terms of students' concept understanding.	This study used the pre-experiment method using a one group pretest-posttest design, which is only one experimental group without using a control group.	The results showed that there was a significant influence of the model Integrated PBL and STEAM towards the creative thinking of high school students (Fhit = 177,189 α = 0,000 < α = 5%). High understanding of student concepts has an impact on thinking skills Creative Higher Students compared to students who have a low understanding of concepts (Fhit = 202,804 α = 0,000 < α = 5%). Interaction The interaction between the STEAM-integrated PBL model and students' initial concept understanding is influential significant to students' creative thinking ability, namely (Fhit = 5.406 α = 0.000 < α = 5%).
Research Development of Steam Approach to Physics Learning in Indonesia: A Systematic Literature Review (Fitria et. al, 2023).	This study aims to review the development of STEAM approach research on physics learning in Indonesia.	Systematic literature review research with content analysis method is used to review articles published from 2018-2022.	The results of the study are the most widely used type of experimental research, the subject of research is at the junior high school level students grade VII and VIII with a sample number of 20- 45 students. Test research instruments are widely used by examining light and optical materials. The variable that is

Title (Researcher, Year published)	Purpose	Method	Result
			often measured is creative thinking skills. Learning media integrated with the PjBL-STEAM model is the most widely used choice. Therefore, research variables that have not been measured are representation skills and higher-order thinking skills aspects of problem solving and physical matter that have never been used for testing are rigid body equilibrium, work and energy, temperature and heat, Newton's laws, electromagnetics, electricity and parabolic motion, so further studies are needed on its implementation with the STEAM approach.
The Effect of Project Based Learning with the STEAM Approach on Critical Thinking Skills in Online Learning at SMK Negeri 12 Malang (Sulastri, 2021).	The purpose of this study was to determine the effect of Project Based Learning with the STEAM approach on critical thinking skills in online learning at Accounting vocational schools.	This study used a quasi-experimental design design with a form of Nonequivalent Control Group Design. The data collection technique uses test sheets in the form of essays totaling ten items. Data analysis techniques using analysis independent sample t-Test with the help of the SPSS application.	The results showed that there were differences in students' critical thinking skills before and after receiving project based learning treatment with the STEAM approach to online learning of service company financial statement materials. The critical thinking ability of students has increased significantly.
The Effect of STEAM Learning on Improving Each Indicator of Students' Creative Thinking in	This study aims to analyze the effectiveness of STEAM learning in improving students' creative thinking	This study used an approach Quantitative approach with quasi-experimental design and non-equivalent pretest-posttest	Based on improvements on Each indicator and the results of regression tests on each indicator, it is shown that STEAM learning has a very

Title (Researcher, Year published)	Purpose	Method	Result
Physics Learning (Witdiya et al., 2023).	ability in physics learning.	control group design design of non-equivalent control groups.	good influence on students' creative thinking skills. STEAM-based learning is recommended to be used as an innovation in physics learning in deep schools in order to develop creative thinking.
Analysis of The Application of The STEAM Approach to Learning In Indonesia: Contributions to Physics Education (Amiruddin et al., 2022)	The purpose of this study was to analyze the application of STEAM learning in Indonesia, especially its contribution to physics education.	Methods used In this study is descriptive qualitative through relevant literature studies with the purpose of the research conducted.	The result of this study is that STEAM can be integrated into a variety of subjects and levels of education. In addition, the application of STEAM can help develop the skills of learners in The 21st century along with technological developments and demands demands in modern times. In physics learning, the application of STEAM Can make students actively involved in the teaching and learning process of physics.
The Influence of STEAM-Based Learning Application on Students' Critical Thinking Ability (Syukri et al., 2022)	This study aims to determine the effect of application STEAM on students' critical thinking skills.	This research is a pseudo-experimental research with one design group pretest-posttest design.	Result indicates that the Pre-test score obtained is at least 5 and the maximum value is 50, while the Post-test score minimum 60 and maximum score of 95, the average increase of students on the final test over compared with the average score of the pretest. The results of data analysis showed a Sig. (2- tailed) value of 0.000 < 0.05. This indicates that H0 is rejected which indicates that there is a difference in students' critical

Title (Researcher, Year published)	Purpose	Method	Result
			thinking outcomes. This shows an increase in students' critical thinking through the application of a STEAM-based learning approach.
The effectiveness of the parental support-based steam approach to increase children's creativity in learning from home during the Covid-19 pandemic (Salsabila, 2021)	The purpose of this study was to determine the effectiveness of the parental support-based STEAM approach to increase children's creativity in learning from home during the COVID-19 pandemic.	This research uses the literature review method by collecting data and phenomena from the best sources.	The results of this study show that the parental support-based STEAM approach is effective in increasing children's creativity in learning from home during the COVID-19 pandemic.
Effect Of Problem-Based Learning On Improvement Physics Achievement And Critical Thinking Of Senior High School Student (Mundilarto, 2017)	The objectives of this study are to find out the effect of applying the model problem-based learning model towards achievement and students' physics learning achievement and critical thinking.	This research is a pseudo-experimental research by using the Pre-Test-Post-Test control group design control group.	The results showed that on average. Average Gain Score of Student Physics Learning Achievement in Experimental Group and Group experiment and control of 0.63 and 0.32 respectively, values. Average Gain Score for Students' Critical Thinking Skills Critical Thinking Experimental and Control Group Students the experimental group and the control group by 0.49 and 0.34 respectively, and The p value of 0.0001 is obtained from the calculation MANOVA thus can be deduced that learning as done in the experimental group is better compared to learning in the control group.
Construction of STEAM (Science, Technology,	This study aims to reconstruct the STEAM learning	This study uses a descriptive qualitative approach with data	The result of this study is the formulation of a combination framework

Title (Researcher, Year published)	Purpose	Method	Result
Engineering, Arts, and Mathematics) learning models with a Design Thinking approach on renewable energy materials (Febriansari, 2022)	model with a combination of design thinking approaches on renewable energy learning materials.	sources from literature.	between the STEAM learning model and design thinking that can be applied to the learning of renewable energy materials.
The Effect of Problem Based Learning (PBL) Model toward Student's Creative Thinking and Problem Solving Ability in Senior High School (Sihaloho, 2017)	This study aims to analyze whether the increase in students' creative thinking and problem-solving skills creative thinking and problem solving of students taught with conventional learning models and problem-based learning models; to analyze whether the improvement is creative thinking and problem-solving skills of students taught with problem-based learning (PBL) models better than conventional learning.	This study is a pseudo-experimental research with a two-group pretestposttest design.	The results showed that: the average gain of students' creative thinking and problem-solving skills Those taught with conventional learning are in the low category and the average gain in the ability to think creatively and solve Creative thinking and ability Problem solving Students taught with problem-based learning models are in the medium category. Average gain of students' creative thinking and problem-solving skills. Creative thinking and problem-solving abilities of students taught with problem-based learning models are better than. Conventional learning. There is a Problem-based learning influence model on creative thinking ability and students' creative and problem-solving abilities.
Improving Students' Creative Thinking Ability Through Problem Based Learning Models on	This study aims to determine the improvement of students' creative thinking ability through the Problem	The research method used was quasi-experimental with Pretest-Posttest Control Group Design.	The results showed that in the experimental class, the average score of students' creative thinking skills n-Gain was 0.78 (high).

Title (Researcher, Year published)	Purpose	Method	Result
Stoichiometric Materials (Rudibyani, 2019).	Based Learning model on Stoichiometry material.		students' creative by 0.78 (high criterion) and in the control class, the average score of n-Gain students' creative thinking skills was 0.52 (criterion students' creative thinking skills amounted to 0.52 (medium criteria).
Study of the STEAM Integrated Challenge Based Learning Model assisted by Sevima Edlink on Creative Thinking Skills (Viona, 2023).	The purpose of this study was to examine the STEAM integrated Challenge Based Learning learning model assisted by Sevima Edlink on students' creative thinking skills.	The research method used is a literature study with techniques of organizing, synthesizing, and identifying, and formulating.	The result of this study is the formation of Sevima Edlink-assisted STEAM-integrated CBL measures based on several analyzed literature and the linkage of the Sevima Edlink-assisted STEAM-integrated CBL model to students' creative thinking skills. It was obtained that STEAM-assisted integrated CBL Sevima Edlink has a positive impact on students' creative thinking skills combined with science, technology, engineering, art, and mathematics. With Sevima Edlink's STEAM-assisted integrated CBL model, students Can solve urgent problems, propose solutions related to real problems and take appropriate actions so as to provide opportunities for students to be able to develop creative thinking skills.
Analysis of constructivism principles in physics learning	This study aims to analyze the application of constructivism learning theory in	Research data collection is carried out through observation	The results of the analysis show that STEAM-based learning carried out has applied

Title (Researcher, Year published)	Purpose	Method	Result
based on Science, Technology, Engineering, Art, and Mathematics (STEAM) (Kartika et al, 2023).	physics-based learning Science, Technology, Engineering, Art, and Mathematics (STEAM).	techniques, interviews, and open questionnaires, where the three data collection techniques are also triangulated to check the validity of the data collected. The research data were analyzed using interactive analysis techniques developed by Miles and Huberman whose Stages are data collection, data reduction, data presentation, and conclusions.	constructivist principles such as using problems in everyday life to stimulate the learning process, the existence of an inquiry process through studies and experiments, there is an encouragement to ask questions and interact with lecturers, to provide opportunities for students to find new knowledge.
Development of PBL-Based LKPD Assisted by PhET Simulation to Improve Science Learning Outcomes on Vibration and Wave Materials in MTs Negeri 1 Bantul (Sumiasyih, 2022)	This study aims to analyze the implementation of learning and improve student learning outcomes through the development of PBL-based LKPD assisted by PhET Simulation on vibration and wave materials.	This research uses LKPD development design with two experiments.	The results of this study provide data on the implementation of learning at the first and second meetings with a percentage of 100% with very good criteria. The results of student responses to this learning obtained a value of 8.94 with a high category. Increased cognitive learning outcomes in vibrational matter with Gain-score calculation at the first meeting was 0.35 increased to 0.56. entered the medium category, with the interpretation of the effectiveness of N-Gain at a percentage of 56-75 categories quite effective. Improved learning on affective aspects, experimental results at the first meeting obtained an average of 75.0 rose to

Title (Researcher, Year published)	Purpose	Method	Result
			86.3 at the second meeting. The results of observations of student activities with an average score of 88.22 at the meeting The first increased to 88.33 at the second meeting with the criteria of excellent student activity. PBL-Based LKPD Assisted by PhET Simulation can be applied to students at the Tsanawiyah madrasah level.
Mathematical Creative Thinking Ability Reviewed from Self-Esteem in PBL Model with STEAM Approach (Fitria, 2023)	The purpose of this study was to determine the effectiveness of mathematical creative thinking skills in PBL models with the STEAM approach and descriptions of mathematical creative thinking skills in terms of self-esteem in PBL models with the STEAM approach.	The method used is the Mix Method type Sequential Explanatory Design.	Learning using the PBL model with a STEAM approach is effective in improving mathematical creative thinking skills. The ability to think creatively in mathematics of high self-esteem students meets four indicators, namely fluency, flexibility, originality, and elaboration. Students with moderate self-esteem may use their own language in new and distinctive ways, or in other words , student fluency is fulfilled. But it differs in terms of ability, flexibility, originality, and elaboration. Students with low self-esteem can understand the problem, but four indications of fluency, flexibility, originality, and elaboration have not been met.
Effectiveness of STEAM-based blended learning	This research aims to improve students' critical and creative	This research is a pseudo-experimental research This study	The results show steam-based blended learning can be improved.

Title (Researcher, Year published)	Purpose	Method	Result
on students' critical and creative thinking skills (Agnesi, 2023)	thinking skills through the utilization of Science, Technology, Engineering, Art, Mathematics (STEAM) blended learning.	used a pretest-posttest nonequivalent control group design.	Ability to think critically and creatively on all indicators with moderate to high category. The increase in students' critical and creative thinking skills in the experimental class was higher than in the control class. In addition, there are differences in learning outcomes between the control class and the experimental class. STEAM-based blended learning can be an alternative for teachers to solve problems of low critical and creative thinking skills.
Application of Steam-based PBL model for Improving Student Learning Outcomes (Putri et al., 2025)	Aims to determine the improvement of chemical cognitive learning outcomes by application of Problem Based Learning (PBL)-based learning model Science, Technology, Engineering, Arts And Mathematic (STEAM).	Data collection techniques used in the form of tests and sheets Observation (observation).	Based on observations, it shows that in cycle II there was an increase in student learning outcomes by 81.71 with a percentage of 71% when compared to the first cycle of 70.57 learning using the PBL model gets the same responses. good from learners.
The Effect of STEAM-Based Hybrid Based Learning Model on Students' Critical Thinking Skills (Wasito, 2023)	The purpose of the study was to determine the effect of STEAM-based hybrids Learning model based on students' critical thinking skills.	This research is a type of meta-analysis research. The research data came from 15 national and international journals. The process of searching for data sources through the Google Scholar, Science database Live, Eric, Plos ONE and Wiley. The data selection method is Preferred Reporting Item for the method of	The results of the study concluded that the summary effect size or average effect size (p <0,01; ES = 1.052) strong criterion. This finding explains that the hybrid-based learning model has a significant effect on students' critical thinking skills. The STEAM hybrid-based learning model has a higher influence on student criticality thinking skills

Title (Researcher, Year published)	Purpose	Method	Result
		Systematic Review and Meta-Analysis (PRISMA).	compared to conventional models. Models have a higt influence on students. Critical thinking skills compared to conventional models.

Discussion

In the table of articles listed above, with 20 articles related to the STEAM-integrated PBL model to improve students' creative thinking, using the STEAM-integrated Problem-Based Learning model can improve students' creative thinking patterns. Several articles show that using the STEAM-integrated PBL model results in an increased creative mindset of students. STEAM itself has a component that emphasizes student creativity in solving a problem with science techniques, especially in physics. In addition, STEAM learning, teachers, or educational institutions will help the progress of the Indonesian education system. Because with the application of STEAM learning, you can prioritize problem-solving-based learning. So that students will be trained in psychomotor, cognitive, and affective aspects. In learning Physics, it is necessary to emphasize critical and creative thinking to make problem-solving easier, especially in everyday life.

From the analysis of 20 articles that have been reviewed, several new relevant findings regarding STEAM-based learning innovations were found. STEAM-PBL integration is proven to be effective in increasing student creativity. This is supported by articles 1, 3, 6, 10, and 14, which show that the STEAM-based PBL approach can encourage student creativity better than conventional methods. The main contributing factor is the project-based approach that allows students to develop innovative solutions. Then, Collaboration between disciplines, especially by adding aspects of art in STEAM learning. In addition, STEAM-PBL not only contributes to the creativity aspect but also has the potential to improve critical thinking skills and problem-solving skills (Fitria et al., 2023). Articles 2, 5, 8, 12, and 17 show that STEAM-PBL integration supports the development of better critical thinking skills. Some factors contributing to this improvement are Challenge-based learning, where students are given real problems to solve (Budiyono et al., 2020) and the combination of theory and practice, which makes students understand concepts more deeply.

The Use of technology and digital media in STEAM-PBL further strengthens learning effectiveness. Articles 1, 14, and 16 highlight how digital media, such as interactive comics and PhET simulations, can improve students' understanding of concepts. Key findings include the visualization of abstract concepts in physics, which is becoming easier to understand. The Use of interactive applications increases student engagement in learning. In addition, contextualizing learning in everyday life helps students

understand physics concepts. Articles 7, 9, and 18 show that a project-based approach with STEAM-PBL can help students connect theory with the reality they face around them. This connection is strengthened by real problem-based case studies that encourage exploration and innovation and multidisciplinary approaches that make physics more relevant to students' lives.

Relationship of Findings to the Main Objectives of the Study. The main objectives of the articles analyzed were: 'Analysing the profile of STEAM-integrated PBL model designed to improve creative thinking of high school students in physics learning. 'From the analysis of the 20 articles, it can be concluded that the purpose of this study is in line with the main findings obtained, namely that the PBL-STEAM model is proven effective in improving students' creative thinking. This strongly supports the main argument of this research.

In addition, project-based learning with the STEAM approach also contributes to developing 21st-century skills, especially in critical thinking, problem-solving, and innovation. Using technology and digital media in STEAM-PBL can accelerate the understanding of physics concepts, which shows how relevant this learning model is in today's digital era. The STEAM-PBL approach can encourage students' active involvement in learning, making learning more meaningful and engaging. Based on the comparison between the articles and the new findings generated, the STEAM-integrated PBL model is a practical approach to improving the creative thinking of high school students. The findings from these 20 articles also support the relevance of this model to the demands of 21st-century education and contribute to the achievement of the main research objectives that have been set. This model not only enhances students' creativity but also the critical thinking, problem-solving, and innovation skills required in the modern world.

CONCLUSION

Fundamental Findings: Based on the analysis of 20 articles reviewed, it was found that The Problem-Based Learning (PBL) model integrated with STEAM is proven to increase student creativity significantly. Then STEAM-PBL enhances creativity, critical thinking, problem-solving, and innovation skills, essential in 21st-century education. Using digital media and technology in the STEAM-PBL model accelerates understanding of physics concepts and increases student engagement in learning. Contextualization in everyday life through a project-based approach makes physics learning more relevant and meaningful to students. **Implications:** The results of this study have several important implications. For educators, integrating PBL with STEAM can be an effective strategy to improve students' creative thinking in physics learning. For educational institutions, this model can be used as an innovative approach in the curriculum to prepare students to face real-world challenges. For curriculum developers, this research provides a basis for designing STEAM-PBL-based learning that is more effective and contextualized. **Limitations:** Although the STEAM-PBL model shows many benefits,

there are some limitations to this study: Most of the studies analyzed used quasi-experimental, and classroom action research (PTK) approaches, so the generalization of the results is limited. There is a lack of research that addresses the long-term effectiveness of the STEAM-PBL model in improving students' creative thinking. Variations in implementing this model at different levels of education are still limited, so further studies are needed to determine its effectiveness in different contexts. **Future Research:** To strengthen the results of this study, some recommended future research directions are: Further exploration of the long-term effectiveness of the STEAM-PBL model in developing student creativity and testing the STEAM-PBL model at various levels of education and other subjects to see the sustainability of its impact. Use more innovative technologies, such as artificial intelligence or virtual reality, to implement STEAM-PBL to enhance students' learning experience. Analyze the supporting and inhibiting factors in implementing this model in different school environments, including teacher constraints and available facilities.

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