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The Innovative Physics Learning Model to Improve Creative Thinking Skills: a Systematic Literature Review

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Abstrak

The aims of this paper is to describe an innovative physics learning model in developing creative thinking skills. The studies carried out were 1) indicators of creative thinking skills, 2) ways to develop creative thinking skills. This study is a Systematic Literature Review which is carried out by identifying, reviewing, evaluating and interpreting all research that has been carried out and written in the form of scientific articles. The design used is to summarize and review 20 articles that have a specific focus on research objects in journals indexed by Scopus. The results of the study state that 1) the indicators of creative thinking skills that are widely used in research are Guilford and Torrance's creative thinking; 2) there are various innovative physics learning models that can be implemented to develop creative thinking skills, including project-based learning models, STEM-based learning models, problem-based learning models, flipped classrooms, and technology-assisted learning models.

Keywords : *creative, learning, physics*

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INTRODUCTION

To explore the current state of creative thinking skills among Indonesians, several studies provide insights into different aspects of creative thinking and its development. Creative thinking skills are essential competencies in the modern era, particularly within 21st-century education (Mulyono, et al., 2023). The rapid advancement of technology and information necessitates individuals to possess flexible, innovative, and adaptive thinking abilities. Creative thinking enables students to tackle complex challenges, discover new solutions, and contribute across various fields of science and industry. Many research show that creative thinking skills are crucial not only for innovation and problem-solving but also for personal and professional development. According to OECD (2017) emphasizes that critical and creative thinking skills are key to success in the digitalization era. So that to effectively participate in a constantly evolving society, students must be trained to think creatively and critically.

Various learning model have been developed to enhance students' creative thinking skills. One prominent learning model is project-based learning (PjBL), which allows students to work collaboratively in solving real-world problems (Widiarini et al., 2022). According to Khoiri et al. (2023), the use of PjBL through traditional games significantly improves students' creative thinking, critical thinking, and collaboration skills. Additionally, the Creative Problem Solving (CPS) method combined with flipped classrooms has also proven effective in enhancing students' creative thinking skills. Rahayu et al. (2022) found that the combination of CPS and flipped classrooms is more effective than CPS alone in the context of online learning. The flipped classroom model offers flexibility in learning, enabling students to independently study basic materials and use classroom time for discussions and practical applications. Digital storytelling is another method used to develop creative thinking skills. Irma et al. (2023) demonstrate that the use of digital storytelling not only enhances students' creativity but also their digital literacy. This method combines narrative with multimedia technology, creating an engaging and interactive learning environment.

While various methods have been identified as effective ways to enhance creative thinking skills, several challenges need to be addressed. For instance, Akmam et al (2023) highlights the importance of metacognitive strategies in physics education, where students need to be taught to manage their learning processes more effectively. Culturally-based approaches also play a significant role in enhancing creative thinking skills. Syefrinando et al. (2022) show that ethnoscience-based learning models, which integrate local cultural knowledge into science education, can make learning more contextual and relevant for students, thereby improving their understanding and attitudes towards science. Furthermore, a study on the correlation between scientific attitudes and creative thinking skills among chemistry education students emphasizes the significance of data collection using scientific attitude instruments and creative thinking test items Yuliatin et al. (2021). Furthermore, the impact of implementing Project-Based Learning (PjBL) on physics students' critical and creative thinking skills defines creative thinking skills as the capacity to uncover truths, problems, ideas, and solutions (Ananda et al., 2021). Research on models like Blended Learning ANTASARI shows notable enhancements in critical thinking and problem-solving skills among students following the adoption of innovative teaching models (Suriansyah & Setiawan, 2021). Moreover, the role of STEM Project-Based Learning (PjBL) in evaluating students' science process skills and creative thinking skills highlights the positive outcomes in improving creative thinking skills (Suryaningsih & Nisa, 2021). The development of E-Modules based on Flip PDF Professional to enhance students' creative thinking skills in science education demonstrates the potential of digital tools in nurturing creative thinking abilities (Hasanah et al., 2023). Furthermore, the integration of Project-Based Learning with STEM (PjBL-STEM) emphasizes how creative thinking skills encourage students to be more engaged in learning, enabling them to articulate opinions and process information more effectively (Mamahit et al., 2020).

Innovative technology-assisted learning is crucial in enhancing students' creative thinking skills. Research emphasizes the importance of guiding students in critical and creative thinking to equip them with the necessary skills for the 21st century (Sumarni & Kadarwati, 2020). Teachers can utilize innovative teaching models like project-based learning and Higher Order Thinking Skills (HOTS)-based learning to nurture students' critical and creative thinking abilities effectively (Supriandi, 2023). Training programs focusing on designing innovative 21st-century learning have been shown to enhance teachers' understanding and skills in creating engaging learning experiences, highlighting the necessity for diverse training in learning technologies (Marhamah, 2024). The integration of digital media, such as video learning using applications like Canva, in 21st-century education demands teachers to be innovative and creative in developing high-level thinking skills in students (Rahmawati & Atmojo, 2021). Implementing STEM Project-Based Learning (PjBL) not only offers students freedom, challenges, and motivation but also enhances their creative thinking, analytical skills, and overall higher-order thinking abilities (Firmantara, 2023). Additionally, models like Cooperative Learning have been identified as suitable approaches to enhance critical and creative thinking skills in students (Twiningsih & Retnawati, 2023). Models like Problem-Based Learning (PBL) have been recognized for their ability to enhance students' problem-solving skills, memory retention, and capacity to improve higher-order thinking skills, particularly creative thinking (Sulastri et al., 2022). Similarly, the integration of Local Wisdom Integrated Science (LWIS) in STEM education has been suggested as a solution to address the lack of creative thinking skills among students resulting from conventional teaching methods (Apriliana et al., 2023). Furthermore, innovative teaching strategies such as online Project-Based Learning (PBL) and creative thinking have been found to enhance students' science process skills in elementary education (Cahyana & Nurjanah, 2021). In conclusion, the amalgamation of these references underscores the significance of leveraging innovative, technology-assisted teaching methods to cultivate creative thinking skills among students. By incorporating various models like PBL, STEM, and HOTS-based learning, educators can effectively nurture critical and creative thinking abilities essential for students to thrive in the modern educational landscape. Thus, the focus of this research aims to obtain a comprehensive overview of creative thinking skills in solving physics problems through content analysis about the development of indicators of creative thinking skills and how to improve creative thinking skills.

METHODS

The method used in this study is Systematic Literature Review (SLR). The systematic review carried out follows a clearly defined protocol or plan and the criteria are clearly stated before the review is carried out (Zarate et al., 2022). This review identifies all types of information regarding creative thinking indicators and innovative learning model that can develop creative thinking skills in physics learning which were reported in the last 5 years.

The object of this study is indicators of creative thinking and strategies to improve students' creative thinking skills. The data collected in this SLR is evaluated based on quality assessment criteria questions, namely: (1) is the journal indexed by Scopus?; (2) whether the journal article was published in the period 2019-2024?; and (3) whether the journal article mentions information on creative thinking indicators, as well as how to generate and/or improve students' creative thinking skills in physics learning. The inclusion and exclusion criteria set out in this SLR study are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

Criterion	Description
Inclusion	The data used are journal articles for the last 5 (five) years from 2019-2024. Data are taken from journal indexed by Scopus. Data outlines the indicators of creative thinking skills and how to improve creative thinking skills in physics learning
Exclusion	The data does not contain complete indicators of creative thinking. The data does not address how to generate or improve creative thinking skills in physics learning

Researchers collected journal articles from Scopus. The key word in this study is creative thinking skills. From the results of the article search, 200 document articles were found with the scope of discussion of creative thinking skills in physics learning. The identified articles will go through several processes according to the PRISMA chart (Zarate et al., 2022).

Based on the objects and criteria of inclusion and exclusion that have been described above, in this study 50 articles have been identified. The identified articles will go through several processes according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) chart which consists of 4 main steps, namely identification, screening, eligibility and included. The PRISMA chart can be observed in Figure 1.

RESULT AND DISCUSSION

Based on the results of article searches using Scopus databases, a total of 47 articles were obtained that matched the keywords of creative thinking skills in physics learning in the last 5 years, namely 2019-2024. Then the articles obtained were narrowed down by referring to the chosen topic, namely the use of innovative learning for creative thinking skills, so as to produce 20 articles that will be analyzed in more depth. The 20 articles analyzed were obtained were narrowed down by referring to the chosen topic, namely the use of innovative physics learning for improving creative thinking skills, so as to produce 20 articles that will be analyzed in more depth. The 20 articles analyzed were sourced from international journal sources, where the results of the meta-analysis of the article findings are presented in Table 2.

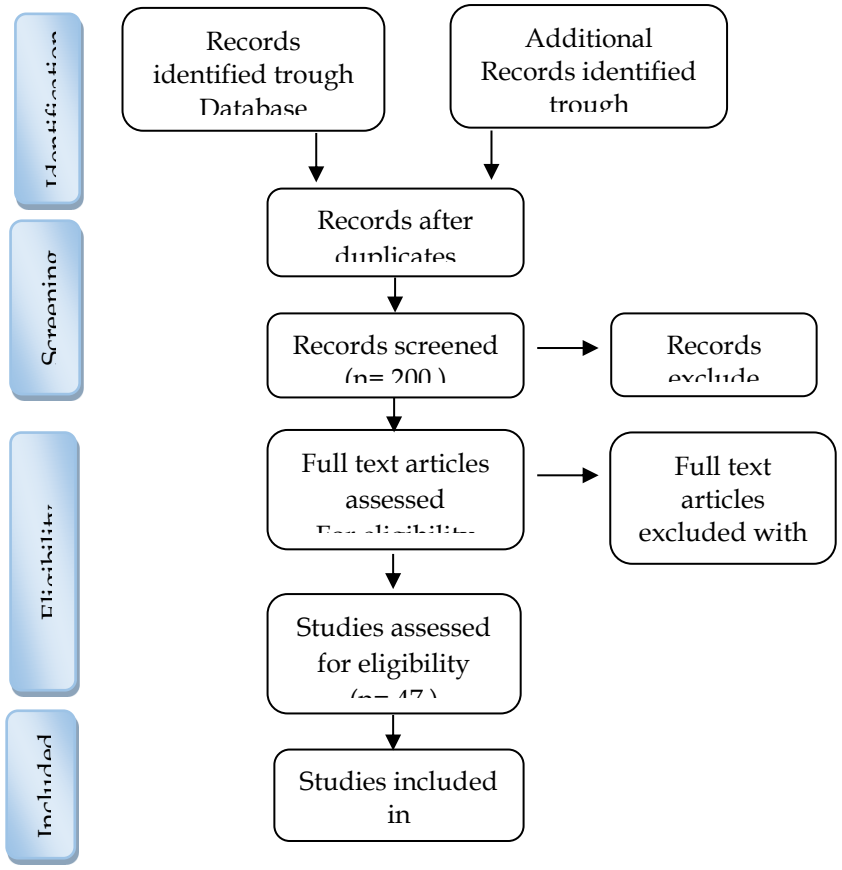

Figure 1. Chart Preferred Reporting Items for Systematic Reviews and Meta-analyses

Table 2. Meta Results of Creative Thinking Skills Concept Findings

No	(Author's Name, Year)	Research Methods	Creative Thinking Indicators Used	How to Develop Creative Thinking
1	Akmam et al., 2023	A combination of explanatory sequential design research methods	Indicator of creative thinking is fluency, flexibility, elaboration, originality, flexibility and analysis, evaluation.	Generative learning models based on cognitive conflict with metacognitive process in learning computational physics
2	Antomi et al., 2020	A quasi experimental research with a non-equivalent control group design	Using creative thinking skills in general	STEM-inquiry rainstorming in static fluid material
3	Asrizal et al., 2024	A quasi-experimental study with post-test-only control group design	Indicator of creative thinking skills are Asking Lots of Questions (ALQ), Giving Various Ways (GVW), Giving Lots of Answers (GLA) and Giving Various Reasons (GVR)	STEM-Smart Physics E-Module

No	(Author's Name, Year)	Research Methods	Creative Thinking Indicators Used	How to Develop Creative Thinking
4	Desnita et al., 2022	a non-equivalent pretest-posttest control group design	Referring to 6 aspects developed by the research team	CTL-based Physics E-module in global warming topic
5	Hadjarati et al. 2019	Quasi Experimental	Using creative thinking skills in general	The use of Edmodo e-learning as innovative learning
6	Irma et al., 2023	Embedded experimental design with mix-methods approach	Referring to Guilford which consists of 4 aspects, namely fluency, flexibility, originality, and elaboration	Application of STREM PBL with e-authentic assessment and essay test model on static fluid materials
7	Jumadi et al., 2021	Quasi experimental	Referring to Guilford which consists of 4 aspects, namely fluency, flexibility, originality, and elaboration	The use of collaborative learning combined with google classroom
8	Khoiri et al., 2023	Pre-experiment with one group pretest-posttest method	Referring to Torrance (TTCT) which was then developed by researchers using indicators: 1) improvisation, 2) elaboration, 3) creative and visionary, 4) effective and efficient	Implementation of project-based learning using traditional games
9	Kurniawan et al., 2024	A quasi-experimental research with pre-test and post-test nonequivalent control group design	Referring to 6 aspects developed by the research team	Synectic-HOTS-oriented learning model in energy and work topics
10	Novitra et al., 2021	The preliminary research stage of Plomp's development design	Referring to 6 aspects developed by the research team	Networked-based inquiry model
11	Pont-Niclòs et al., 2023	Quantitative research with cross-sectional design	Referring to Torrance (TTCT) which assesses three aspects of creative thinking, including: 1) Fluency, 2) Flexibility, and 3) Originality	Give students the opportunity to write different questions based on everyday experience based on science, having students come up with questions that relate to an image of an Austronaut standing on the moon
12	Rahayu et al., 2022	Quasi-Experimental	Referring to Guilford which consists of 4 aspects,	Creative problem solving-flipped classroom

No	(Author's Name, Year)	Research Methods	Creative Thinking Indicators Used	How to Develop Creative Thinking
			namely fluency, flexibility, originality, and elaboration	
13	Rizal et al., 2024	Quasi-experimental study with a non-equivalent control group design	Referring to Guilford which consists of 4 aspects, namely fluency, flexibility, originality, and elaboration	Problem-based learning management system (pblms): a mobile learning application in dynamic electricity
14	Rokhmat et al., 2022	Quasi-Experimental type using untreated control group design with pretest and posttest.	Referring to Guilford which consists of 4 aspects, namely fluency, flexibility, originality, and elaboration	Use of causalitic learning model in momentum and impulse topics
15	Rufaida & Nurfadilah, 2021	A pre-experimental research with one group pretest postest design	Referring to Guilford which consists of 4 aspects, namely fluency, flexibility, originality, and elaboration	Hypercontent module
16	Sajidan et al., 2022	Quasi-experiment (one group is given Pretest-Posttest)	Referring to 5 aspects developed by the research team, namely fluency, originality, elaboration, evaluation, and presentation	Application of the science integrated learning model with digital assessment in practicum activities
17	Serevina et al., 2020	Classroom action research	Referring to Guilford which consists of 4 aspects, namely fluency, flexibility, originality, and elaboration	Discovery learning model in temperature and heat topics
18	Simanjuntak et al., 2021	Quasi-experiment (3 groups were given pretest and posttest)	Referring to Guilford which consists of 4 aspects, namely fluency, flexibility, originality, and elaboration	Application of problem-based learning model with computer simulations and the provision of essay tests and problem-based tests on the topic of impulses, momentum, and harmonic motion
19	Syefrinando et al., 2022	Quasi-experiment	Referring to creativity, according to Morney, there are 4 aspects, namely the ability to respond, the ability to engage in discovery, the ability to intellect, and the ability to create something new	Use of creativity observation sheets to evaluate video projects that have been created. There is a significant influence of digital literacy and self-regulation on creativity

No	(Author's Name, Year)	Research Methods	Creative Thinking Indicators Used	How to Develop Creative Thinking
20	Syukri et al., 2022	Quasi-Experimental with a non-equivalent control group design	Referring to the 4 aspects developed by Guilford fluency, flexibility, originality, elaboration,	PBL based on blended learning

Based on the results of the review in Table 1, it appears that all articles apply innovative physics learning to various physics topics to develop creative thinking skills. Innovative learning models implemented include flipped classroom, project based learning, generative learning model with metacognitive processes, stem PBL, technology-assisted learning, and others. The topics of discussion that most often appear in each article as well as the possibility of future research studies can be summarized as shown in Table 3.

Table 3. Summary of Discussion Topics and Opportunities for Further Studies

No	The Majority of Discussion Appear in Articles	Analysis of Implications and Limitations	Further Study Opportunities
1	The indicator of creative thinking refers to the opinion of Torrance, Guilford, Morrney or others.	45% of articles use creative thinking indicators according to Guilford. 10% of the articles used creative thinking indicators according to Torrence, 5% used creative thinking indicators according to Morney and 40% used other creative thinking indicators. Interestingly, articles that use other creative thinking indicators have some aspects of the indicator in common according to Guilford and Torrence but there are some additional variations of the indicator. In this case, the interpretation between one article and another of the indicators of creative thinking referred to is different.	It is necessary to develop and test the consistency and/or effectiveness of each indicator of creative thinking by Guilford and Torrance.
2	Developing creative thinking skills in Physics through a learning model	All articles examine the development of creative thinking skills using various learning models. 40% of articles use learning models that are not combined with the use of technology such as e-modules, e-assessments, hybrid learning, virtual labs, and the like. The topics analyzed include dynamic electricity, temperature and heat, impulse and momentum.	This requires efforts to teach physics topics with learning models that can develop indicators of creative thinking skills, for example project-based learning models with metacognitive strategies.
3	Developing creative thinking skills with a combination of learning approaches and technology	As many as 60% of the article analysis results use a combination of physics and technology learning. The rest use project based learning, discovery learning, problem based learning, flipped classroom, and STEM-inquiry learning.	It is necessary to develop and combine learning models with technology to facilitate physics learning activities, for example using flipped classroom and virtual labs to conduct the learning process.

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High order thinking skills are thinking skills that are developed in science through a practicum process (Sajidan, et al., 2022). Creative thinking is part of higher level thinking which requires teacher efforts in developing student creativity (Izzah, et al., 2023). There are various aspects of creative thinking developed by researchers. Sajidan, et al., (2022) put forward 5 aspects of creative thinking, namely fluency, originality, elaboration, evaluation, and presentation. Syefrinando, et al., (2022) refer to the creative thinking aspect of Morney, namely there are 4 aspects including the ability to respond, the ability to be involved in discovery, intelligence ability, and the ability to create something new. Referring to Torrance who assesses three aspects of creative thinking including: 1) Fluency, where children can provide many ideas with words; 2) Flexibility, namely children can provide various ideas, shift from one approach to another, or use various strategies; 3) Originality, the child's ability to produce unusual ideas (Izzah, et al., 2023; Pont-Niclòs, et al., 2023).

According to Guilford, the criteria for creative thinking are fluency, flexibility, originality and elaboration. These four aspects of creative thinking have been used in several studies conducted to measure creative thinking skills such as research by Irma, et al., (2023), Jumadi, et al., (2021), Rahayu, et al., (2022), Simanjuntak, et al., (2021), Syukri, et al., (2022), and Yonwong, et al., (2024). Fluency, namely the ability to express similar ideas to solve a problem. Flexibility, namely the ability to generate various kinds of ideas to solve a problem outside the usual categories. Originality, namely the ability to provide a unique or extraordinary response. Elaboration (detail), namely the ability to express the direction of an idea in detail to turn the idea into reality. Creative thinking indicators encompass various aspects that are crucial in assessing an individual's creative abilities. In educational settings, creative thinking assessments often revolve around indicators such as fluency, flexibility, originality, and elaboration, which are essential in gauging students' creative thinking abilities (Saputri et al., 2022).

To enhance creative thinking skills through a combination of learning approaches and technology, a strategic integration of pedagogical goals with technology is crucial. Utilizing technology in education can improve personalized learning experiences, create interactive and immersive learning environments, foster digital literacy skills, and promote critical thinking and creativity (Eden, 2024). Research has shown that incorporating Project-Based Learning (PjBL) integrated with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach can indeed enhance creative thinking skills (Rahayu et al., 2023). Moreover, the use of information technologies in learning environments can offer students creative learning opportunities, enabling them to develop high-order thinking skills and enhance creative thinking (Kincal et al., 2016). Digital technologies like virtual learning ecosystems and gamification have been found to stimulate creative thinking and innovation skills, highlighting the positive impact of technology on nurturing creativity (Wannapiroon & Petsangsri, 2020). Additionally, technology-supported learning approaches, such as the STEAM method, have been proven to significantly boost students' creative thinking abilities by providing engaging problem-solving experiences and encouraging innovative solutions (Mulder, 2024). The integration of technology in education can also aid in the development of 21st-century skills, encompassing communication, collaboration, critical thinking, creativity, and digital literacy (Li, 2024). In conclusion, the strategic use of technology alongside innovative learning approaches like PjBL, STEAM, and digital tools can effectively cultivate creative thinking skills among students. By establishing dynamic and interactive learning environments that leverage technology, educators can empower students to think critically, solve problems creatively, and adapt to the demands of the modern world.

Developing creative thinking skills is crucial in the current educational landscape and workforce due to several reasons supported by various studies. Firstly, a study on the importance of creative thinking skills in the 21st century highlights how these skills are essential for problem-solving, innovation, and adapting to rapid changes in technology and society. Secondly, research on the correlation between creative thinking skills and academic achievement emphasizes that students with higher creative thinking skills tend to perform better academically across various subjects. Overall, creative thinking skills are crucial components of 21st-century education. Recent research indicates that innovative teaching approaches such as PjBL, CPS, flipped classrooms, and digital multimedia have great potential for enhancing students' creative thinking skills. Future research should continue to explore and refine these strategies to ensure their widespread adoption and success in diverse educational contexts. Today, more

comprehensive efforts are needed to optimally develop creative thinking skills. A combination of immersive learning approaches, flipped classrooms, and project-based learning models can be used as a learning model that can optimize the development of students' creative thinking skills. The hope is that students will become increasingly accustomed to optimizing their thinking abilities to become creative and competitive individuals. Continuous efforts in research and development of creative learning methods are necessary to ensure that students are well-prepared to face future challenges and opportunities.

CONCLUSION

The indicators of creative thinking skills that are most widely used in physics learning research are those that refer to Guilford. According to Guilford, there are four aspects of creative thinking skills, namely fluency, flexibility, originality and elaboration. Innovative physics education plays a crucial role in developing students' creative thinking skills. Various teaching models focusing on active engagement, problem-solving, and the use of technology have shown significant effectiveness in enhancing student creativity. Overall, the implementation of innovative physics education models has proven effective in developing students' creative thinking skills. Approaches such as PjBL with traditional games, the combination of CPS and flipped classrooms, digital storytelling, metacognitive strategies, and ethnoscience-based learning provide various ways for students to actively engage in the learning process, foster creative thinking, and address the challenges of 21st-century education. Adopting these models in physics education not only makes learning more interesting but also equips students with the skills they need to succeed in the future.

RECOMMENDATION

Based on the SLR results, a learning model that integrates technology and provides ample learning time can be implemented to optimally develop creative thinking skills. One science learning model, especially physics, that can be developed is a learning model that adopts project-based learning, in-depth learning, and flipped classrooms through providing more open, complex, and contextual projects.

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AUTHORS CONTRIBUTION

PW conceived the article and searched for the articles reviewed. IKS, NKR, and IWS assisted in providing input on the SLR method used and in discussing the article review results. All authors have read and approved the published version of the manuscript.

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