Lensa: Jurnal Kependidikan Fisika
Penerbit: Universitas Pendidikan Mandalika
https://e-journal.undikma.ac.id/index.php/Lensa/index
Dec. 2024. Vol. 12, No, 2
e-ISSN:2686-0937
pp. 148-161

The Impact of the Problem-Based Learning Model with a Scientific Approach on Students' Creative Thinking and Design Thinking

Lathifatul Muwafiq Azizah[1], Saiful Prayogi[2], Syifa'ul Gummah[1], Lovy Herayanti[1], Habibi[1,3,*]

[1] Physics Education Department, Universitas Pendidikan Mandalika, Mataram, Indonesia
[2] Science Education Department, Universitas Pendidikan Mandalika, Mataram, Indonesia
[3] Physics Education Department, Universitas Negeri Surabaya, Surabaya, Indonesia

*Corresponding Author: habibi@unesa.ac.id

Abstract

This study investigates the impact of integrating the scientific approach within the problem-based learning (PBL) model on students' creative thinking and design thinking skills, specifically in the context of physics education. The primary objective is to evaluate whether this combined approach significantly enhances these higher-order thinking skills compared to conventional teaching methods. A quasi-experimental design was employed with non-equivalent control groups, comprising two eighth-grade classes: an experimental group receiving the PBL model with a scientific approach, and a control group taught using traditional methods. Pretests and posttests were administered to assess the students' creative and design thinking abilities. Data were analyzed using parametric statistical methods, including normality and homogeneity tests, followed by a paired t-test to evaluate the hypothesis. The results indicated that students in the experimental group showed significantly higher improvements in both creative and design thinking skills compared to the control group. Key dimensions such as comfort with uncertainty, attention to process, and confidence in creativity were notably enhanced in the experimental group. The findings suggest that integrating the scientific approach within PBL fosters an engaging and effective learning environment, promoting not only cognitive development but also collaboration, communication, and problem-solving skills. These results have important implications for educational practices, highlighting the value of adopting student-centered learning models to equip students with the critical skills needed for future challenges.

Keywords: Scientific approach; Problem-based learning; Creative thinking; Design thinking.

How to cite: Azizah, L. M., Gummah, S., Prayogi, S., Herayanti, L., & Habibi, H. (2024). The Impact of the Problem-Based Learning Model with a Scientific Approach on Students' Creative Thinking and Design Thinking. *Lensa: Jurnal Kependidikan Fisika, 12*(2), 148-161. doi: https://doi.org/10.33394/j-lkf.v12i2.11933

INTRODUCTION

In today's fast-paced world, where science and technology are rapidly evolving, the need for a significant transformation in education has become more pressing than ever. This transformation should particularly focus on enhancing students' thinking abilities and skills. Hermawan et al. (2023) highlight the importance of fostering higher-order thinking skills, specifically creative and design thinking, as they are critical in meeting the demands of the modern era. These skills empower students to generate innovative ideas and design solutions to complex problems (Dilekçi & Karatay, 2023; Rösch et al., 2023). As societies navigate the challenges of the 21st century, adaptability and innovation become key to success.

However, despite the growing importance of creative and design thinking, the level of students' creative thinking skills remains low in several countries, including Indonesia. Dewi et al. (2019) report that students in Indonesia exhibit lower levels of creative thinking, a claim further substantiated by the findings of The Global Creativity Index in 2015, where Indonesia ranked 115th out of 139 countries (Florida et al., 2015). This worrying state calls for immediate educational interventions to enhance these critical skills. Consequently, creative and design thinking must be nurtured through appropriate teaching approaches that stimulate these abilities effectively.

One teaching approach that has gained recognition for fostering various essential skills, including creative and design thinking, is the scientific approach. This method emphasizes a structured process, focusing on observation, inquiry, hypothesis formulation, experimentation, and drawing conclusions (Suprihatin et al., 2023; Aka & Mukmin, 2020; Zainudin & Istiyono, 2019; Tarigan, 2021; Azizah et al., 2022). The scientific approach allows students to actively engage with learning material, developing critical and analytical thinking skills that are necessary for solving real-world problems. Through this process, students learn to think systematically, evaluate their findings, and formulate well-founded conclusions, which are key to cultivating both creative and design thinking.

Several studies underscore the effectiveness of the scientific approach in enhancing students' creative thinking abilities. Syahrin et al. (2019), Demir & Isleyen (2015), and Demir Kaçan & Şahin (2018) report that students who engage in learning methods grounded in scientific inquiry exhibit notable improvements in their creative thinking. Wagner et al. (2021) affirm that science lessons incorporating the scientific approach stimulate creative thinking by encouraging students to engage in problem identification, hypothesis formulation, and solution testing. Similarly, Zulfah et al. (2022) observe that students exposed to scientifically-based learning environments demonstrate enhanced innovation and creativity, particularly in their problem-solving abilities.

In addition to promoting creative thinking, the scientific approach also fosters divergent thinking, which is a critical component of creativity. Divergent thinking enables students to generate multiple potential solutions to a problem, considering diverse perspectives before making informed decisions. Klutse (2021) emphasizes that divergent thinking is an essential skill developed through the scientific approach, as it encourages students to approach problems with an open mind and explore various possibilities. Moreover, Azizahwati et al. (2023) highlight that a learning environment conducive to exploration and experimentation can significantly boost students' creativity, encouraging them to develop new concepts and ideas.

Another important aspect of the scientific approach is its application within student-centered learning models such as problem-based learning (PBL). PBL encourages students to work in collaborative groups, explore problems, gather relevant information, and devise solutions (Maharani et al., 2020). This process promotes not only creative and design thinking skills but also crucial interpersonal skills like collaboration and communication. Additionally, PBL coupled with the scientific approach has been shown to enhance students' metacognitive abilities—the ability to be aware of and regulate their own thinking processes (Jelita & Nuraida, 2023). Metacognition is crucial for lifelong learning, as students must constantly learn and adapt in an ever-changing world.

In a PBL framework, the scientific approach also allows teachers to transition from being mere transmitters of knowledge to facilitators of learning. Utomo et al. (2022) argue that in this role, teachers guide students through the learning process, providing personalized support tailored to each student's needs and potential. This shift in the teacher’s role enables a more dynamic and responsive learning environment, where students feel empowered to explore and discover new concepts. The result is a learning experience that is not only cognitively enriching but also highly relevant and engaging, as students apply their knowledge to solve real-world problems.

Moreover, the use of the scientific approach in PBL promotes positive attitudes toward learning. Manda & Marsigit (2021) highlight that students develop a greater appreciation for their studies when they see the practical relevance of the knowledge and skills they acquire. By engaging with authentic problems, students can recognize the value of their learning, which in turn increases their motivation and enthusiasm for continued study. This sense of purpose and relevance is vital in helping students connect classroom learning to the challenges they will face in the broader world.

The benefits of integrating PBL with the scientific approach extend beyond cognitive development. By engaging with real-world problems, students not only enhance their creative and design thinking skills but also develop crucial social and emotional competencies (Syaifuddin, 2017). The collaborative nature of PBL fosters teamwork, communication, and empathy, while the problem-solving process builds resilience and perseverance. These qualities are essential in shaping students into independent, creative, and innovative learners who are well-prepared to navigate the complex and rapidly changing demands of the 21st century.

In light of the challenges associated with teaching complex subjects like physics, this research integrates the scientific approach within the PBL model to stimulate students' creative and design thinking skills. Physics is often perceived as a difficult subject due to its abstract concepts and the need for deep understanding of physical laws and principles. However, by adopting a PBL model that emphasizes the scientific approach, the learning process can become more engaging and accessible to students. The PBL model creates a conducive environment for the development of creativity, as students are encouraged to innovate, experiment, and think critically when solving problems.

The implementation of PBL in physics education is particularly promising because it aligns well with the nature of scientific inquiry. Physics, as a discipline, requires students to engage in systematic observation, experimentation, and hypothesis testing—all of which are core components of the scientific approach. By working on real-world problems in physics, students can apply theoretical concepts in practical settings, which not only enhances their understanding of the subject but also fosters their ability to think creatively and design solutions to complex challenges.

In conclusion, the scientific approach integrated into problem-based learning offers a robust framework for developing students' creative and design thinking skills. By emphasizing scientific inquiry, collaboration, and real-world problem solving, this approach equips students with the cognitive, social, and emotional tools necessary for success in the 21st century. Furthermore, by applying these methods to the teaching of challenging subjects like physics, educators can create a more engaging and effective learning environment that encourages students to think critically, innovate, and continuously improve their problem-solving abilities.

As the demands of the modern world continue to evolve, it is essential that education systems prioritize the development of these crucial skills, ensuring that students are well-prepared to tackle the challenges of the future.

Study objectives

The primary objective of this study is to examine the impact of integrating the scientific approach within the problem-based learning (PBL) model on students' creative thinking and design thinking skills, particularly in the context of physics education.

Novelty of the current study

The novelty of this study lies in its specific focus on integrating the scientific approach within the PBL model to stimulate both creative and design thinking skills in physics education. While prior research has highlighted the benefits of PBL and the scientific approach independently, this study is unique in exploring their combined effect on fostering these two crucial thinking skills simultaneously, especially in a subject like physics. Furthermore, the study addresses a significant gap in the literature by targeting a developing country context, where students' creative thinking abilities are often reported to be lower compared to global standards (Dewi et al., 2019; Florida et al., 2015). This research also contributes to the existing body of knowledge by providing empirical evidence on how PBL with a scientific approach can facilitate not only cognitive development but also the cultivation of social and emotional competencies in students.

METODE

This research employs a quantitative approach in the form of a quasi-experiment. Quasi-experiments aim to predict conditions that can be achieved through actual experiments, even though they do not involve control or manipulation of all relevant variables (Sirotová et al., 2021). The research method is designed using a non-equivalent control group design (Sugiyono, 2013). In this design, there are two groups: the experimental group and the control group, which are not selected randomly.

Data collection in this research is conducted using tests administered through pretests and posttests. The students' abilities at the beginning of the learning process before treatment are shown through the pretest results, while the posttest is used to observe the students' thinking abilities after the treatment, as shown in Table 1 below.

Table 1. Research design

Pretest	Treatmen	Postest
O_1	X	O_2
O_3	Y	O_4

Description:
X: Treatment with problem-based learning model using a scientific approach.
Y: Treatment with conventional methods.
O_1: Experimental group before treatment (pretest)
O_2: Experimental group after treatment (posttest)
O_3: Control group before treatment (pretest)
O_4: Control group after treatment (posttest)

The sample in this research was taken from the population using a sampling technique. This study uses the simple purposive sampling technique, a method where the researcher selects samples based on their knowledge or considerations about the samples to be chosen (Sugiyono, 2013). The population in this study consists of all eighth-grade students of Mts. Al-Qodir Menemeng, with the selected samples being classes VIIIA and VIIIB, consisting of 24 students (experimental group) and 22 students (control group) respectively.

The data collected in this study were analyzed using parametric statistical methods with the help of the SPSS program. The parametric test conducted aims to determine the appropriate hypothesis through a t-test (Akbar et al., 2024). This hypothesis testing aims to assess whether the average creative thinking and design thinking abilities in the experimental group are higher than in the control group. The experimental group received treatment through the implementation of the problem-based learning (PBL) model with a scientific approach, while the control group used conventional methods. The use of the t-test is based on the results of normality and homogeneity tests of the population data with a significance level of 0.05. The t-test applied involves paired and independent tests according to the research conditions (Sutisna, 2020).

RESULTS AND DISCUSSION

The application of the scientific approach in Problem-Based Learning (PBL) can be an effective strategy to enhance students' creative thinking and design thinking abilities. The scientific approach, which involves steps such as observing, formulating questions, collecting data, analyzing information, and drawing conclusions, encourages students to think critically and logically. In the context of PBL, students are faced with complex real-world problems that demand creative solutions. The problem-solving process requires them to combine theoretical knowledge with practical skills, using the scientific approach to formulate hypotheses, test ideas, and revise solutions based on feedback and experimental results. The analysis results of creative thinking and design thinking are as follows.

Students' creative thinking abilities

The primary objective of this study is to examine the impact of integrating the scientific approach within the problem-based learning (PBL) model on students' creative thinking and design thinking skills, particularly in the context of physics education. To achieve this, the research aims to test the hypothesis regarding the significant effect of the scientific approach in the PBL model on students' creative thinking abilities. Before conducting hypothesis testing, prerequisite tests were carried out to ensure the validity and reliability of the statistical analyses, examining key assumptions such as data normality and homogeneity (Sutisna, 2020). The normality test was conducted using the Shapiro-Wilk test, due to the sample size being fewer than 50, and was facilitated through SPSS 29 software, where data is considered normally distributed if the significance value (Sig.) is greater than 0.05.

In addition to testing normality, the study also employed Levene's test for homogeneity to verify that the variance across the groups was consistent, with a significance threshold of 0.05. This ensures the validity of the statistical approach used in hypothesis testing. Both tests confirmed that the data met the required assumptions for further analysis. The results of the normality and homogeneity tests are summarized in Table 2, ensuring that the data is appropriate for reliable hypothesis testing. By integrating these steps, the study aims to rigorously assess how the scientific approach in the PBL model influences the development of creative and design thinking skills in students, which is crucial for enhancing physics education.

Table 2. Data normality and homogeneity test results

Class	Shapiro-wilk		Levene,s test	
	Sig.	**Annotation**	**Sig.**	**Annotation**
Experimental	0,351	Normally Distributed	0,984	Homogeneous
Control	0,282		0,062	

Table 2 presents the significance values for the experimental and control classes, both exceeding 0.05, indicating that the samples in these groups come from a normally distributed population. Additionally, the homogeneity test results show a significance value of 0.984, which is also greater than 0.05, confirming that the pretest data for both classes have homogeneous variances. These two tests are essential prerequisites for conducting the hypothesis test in this study.

The hypothesis test aims to evaluate whether integrating the scientific approach with the problem-based learning (PBL) model has a significant effect on students' creative and design thinking skills. To assess this, a paired t-test was used to compare the average results before and after the treatment. This approach allows for evaluating the changes in students' thinking abilities resulting from the intervention. The results of this hypothesis test are summarized in Table 3, with the decision criteria as follows:

- If the significance value (sig.) is greater than 0.05, there is no significant difference.
- If the significance value (sig.) is less than 0.05, a significant difference is observed.

These criteria determine whether the integration of the scientific approach with PBL effectively enhances students' creative and design thinking abilities, offering insights into the potential benefits of this educational model in fostering critical 21st-century skills.

Table 3. Results of hypothesis testing for experimental and control classes

Pair		Mean	SD	SE	Interval of the		t	df	sig
					Lower	**Upper**			
Pair 1	Pre-exp. Post-exp.	83,0	12,385	2,528	-35,72	-25,27	-12,064	23	0,000
Pair 2	Pre-cont. Post-cont.	67,5	13,880	2,959	-31,15	-18,84	-8,448	21	0,000

The results of the hypothesis test presented in Table 3 reveal a significant difference between the experimental and control classes. The significance (sig.) value for both the pretest and posttest in the experimental and control classes is 0.000, which is less than 0.05 (sig. < 0.05). This finding indicates that the null hypothesis (H0) is rejected, and the alternative hypothesis (Ha) is accepted. In other words, the data suggest a significant effect of the intervention on students' creative thinking skills. The t-value for the experimental class is -12.064, which is negative because the mean score of the pretest is lower than that of the posttest. The paired t-test confirms that there is a statistically significant difference in the performance of the experimental class before and after the treatment.

The average scores further support this conclusion, with the experimental class achieving an average score of 83.0, compared to the control class's average of 67.5. This considerable difference underscores the positive impact of the problem-based learning (PBL) model integrated with a scientific approach on students' creative thinking skills. Students in the experimental class, who experienced the PBL model, outperformed those in the control group, which received conventional instruction. These results demonstrate that the PBL model, combined with the scientific approach, enhances students' abilities to think creatively and solve problems.

This study's findings are consistent with existing research on the efficacy of the scientific approach in conjunction with PBL. Several studies highlight that integrating these two methods encourages student collaboration, promotes idea exchange, and fosters a constructive environment for feedback (Jelita & Nuraida, 2023; Masitoh & Prasetyawan, 2020). Hidayati & Retnawati (2016) suggest that PBL, reinforced by the scientific approach, enhances students' ability to work in teams, communicate effectively, and collaboratively seek the best solutions to complex problems. These skills are essential not only for academic success but also for preparing students to navigate real-world challenges that require creativity, innovation, and teamwork.

The use of the scientific approach within the PBL model trains students to approach problems systematically. This method encourages them to observe, formulate hypotheses, collect and analyze data, and draw conclusions—all essential components of scientific inquiry (Chairuddin & Farman, 2019). By confronting students with real-world problems, PBL encourages them to apply critical and creative thinking skills to generate and test innovative solutions. In doing so, students enhance their conceptual understanding and develop the ability to critically evaluate information, which is vital for effective problem-solving.

Moreover, this integration creates a dynamic learning environment that stimulates creative exploration. Students are encouraged to generate diverse ideas, experiment with various approaches, and adapt based on feedback and results. Such a process is crucial for fostering creativity, as it allows students to break free from conventional thinking and develop unique, effective solutions to complex problems. The scientific approach in PBL promotes flexibility in thinking, encouraging students to view problems from multiple angles and refine their solutions through experimentation and reflection.

In addition to fostering individual creativity, the PBL model also emphasizes collaboration, which is further enhanced by the scientific approach. Working in teams, students must collectively formulate hypotheses, conduct experiments, and analyze data. This collaborative process not only strengthens students' creative and critical thinking skills but also builds essential interpersonal skills such as communication, cooperation, and conflict resolution. These skills are indispensable for success in both academic and professional settings, where teamwork and collaboration are often necessary to solve complex problems.

The integration of the scientific approach in PBL also contributes to the development of metacognitive skills. By reflecting on their learning processes, students become more aware of their thinking patterns and strategies. This metacognitive awareness enables them to identify their strengths and areas for improvement, allowing them to take a more active role in their learning. The ability to monitor and regulate one's thinking processes is essential for lifelong learning, as it helps students adapt to new situations and continue to grow intellectually and creatively.

Overall, the integration of the scientific approach within the PBL model offers a powerful framework for enhancing students' creative and design thinking skills. It promotes a more engaging and active learning process, encouraging students to experiment, explore, and collaborate in solving complex problems. The combination of these methods prepares students to face real-world challenges with the skills and confidence needed to succeed in a rapidly changing, innovation-driven world.

In conclusion, the significant improvement in creative thinking skills observed in the experimental class demonstrates the effectiveness of the PBL model integrated with the scientific approach. This instructional method not only enhances students' ability to think critically and creatively but also equips them with the tools to approach problems systematically and work collaboratively. By fostering these essential skills, the scientific approach in PBL provides a meaningful and applicable learning experience, preparing students to meet the demands of the 21st century with adaptability, innovation, and teamwork.

Students' design thinking abilities

The research results concerning students' design thinking skills were analyzed using data from the experimental and control class samples (see Table 4). To measure students' design thinking competencies, the researcher employed a questionnaire developed and validated by Ladachart et al. (2022) called the Design Thinking Scale. This scale consists of 30 questions designed to assess various aspects of design thinking. The questionnaire evaluates six key dimensions: comfort with uncertainty and risk (DT-1), focus on human-centeredness (DT-2), attention to the process and its impact on others (DT-3), collaboration with diverse perspectives (DT-4), learning orientation through creation and testing (DT-5), and confidence and optimism in utilizing creativity (DT-6). The data were analyzed using descriptive statistics, with a focus on the standard deviation to assess the variability in students' responses between the experimental and control classes. A larger standard deviation indicates greater variation in students' design thinking abilities, suggesting a broader range of skills developed within the class. This analysis provides insights into how effectively the instructional methods used in the experimental class influenced students' design thinking compared to the control class. By examining the six dimensions, the study offers a comprehensive understanding of how students approached design thinking, including their comfort with uncertainty and collaboration in a creative, problem-solving context.

Table 4. Results of hypothesis testing for experimental and control classes

Dimention	Class	N	Mean	SD
DT1: Comfort with uncertainty and risk	Experimental	24	17,5000	5,11604

Dimention	Class	N	Mean	SD
	Control	22	13,5455	4,97352
	Total	46	15,6087	5,37682
DT2: Focus on human-centeredness	Experimental	24	9,9167	2,18526
	Control	22	9,6364	3,36007
	Total	46	9,7826	2,78019
DT3: Attention to the process and its impact on others	Experimental	24	7,7917	2,12601
	Control	22	7,0455	2,55375
	Total	46	7,4348	2,34428
DT4: Collaboration with diverse perspectives	Experimental	24	13,0000	3,61158
	Control	22	12,3636	4,88482
	Total	46	12,6957	4,23147
DT5: Learning orientation through creation and testing	Experimental	24	11,1667	3,26599
	Control	22	10,1364	3,75811
	Total	46	10,6739	3,50906
DT6: Confidence and optimism in utilizing creativity	Experimental	24	19,4091	8,84070
	Control	22	19,2083	6,57386
	Total	46	19,3043	7,65323

Table 4 illustrates that the design thinking (DT) abilities of students in the experimental class are superior to those in the control class. However, two specific dimensions—focus on human-centeredness (DT-2) and collaboration with diverse perspectives (DT-4)—show higher standard deviation scores in the control class. This suggests that, for these particular aspects of design thinking, the conventional learning model outperforms the scientific approach integrated within the problem-based learning (PBL) model.

The conventional learning model, characterized by a teacher-centered approach with lectures and direct instruction, tends to emphasize structured knowledge transmission. While often critiqued for its lack of interactivity, it has the strength of providing students with a clear, organized understanding of fundamental concepts. This structured delivery is particularly beneficial for developing a focus on human-centeredness (DT-2). In this context, students gain a deep foundational understanding of material, which is an essential step in grasping the complexities of human behavior and interaction. Although the scientific approach promotes active learning and student engagement, conventional methods may provide a more stable framework for students to internalize the basics of human-centered design.

Furthermore, the conventional learning model offers teachers the opportunity to play a crucial role in guiding students through complex concepts, linking theoretical knowledge with real-life applications (Rahuma & Ananda, 2019). In the dimension of human-centeredness (DT-2), the direct feedback and structured instruction provided by teachers can establish a solid groundwork, enabling students to appreciate the human aspects involved in design thinking. Although this model may lack the explicit engagement with human-centeredness found in more interactive teaching approaches, its emphasis on foundational knowledge ensures that students are well-prepared to apply this understanding in diverse contexts.

Similarly, the influence of conventional teaching methods on collaboration with diverse perspectives (DT-4) reveals mixed results. On the one hand, conventional methods provide students with a shared knowledge base, which serves as a strong foundation for collaborative efforts. With a clear and structured understanding of the material, students are equipped to engage in discussions, offering and evaluating ideas from a common starting point. However, these methods often lack the flexibility and openness that more modern, student-centered approaches—such as PBL—offer for fostering collaboration. Conventional teaching tends to be more rigid, often limiting opportunities for students to explore differing viewpoints through open discussions. Nonetheless, teachers in a traditional learning environment can still facilitate collaboration by organizing group activities, guiding discussions, and promoting teamwork within structured classroom settings.

Despite these strengths of conventional teaching, the experimental class, which utilized the scientific approach integrated with PBL, demonstrated significantly higher performance in other design thinking dimensions, particularly in DT-1 (comfort with uncertainty and risk), DT-3 (attention to the process and its impact on others), DT-5 (learning orientation through creation and testing), and DT-6 (confidence and optimism in utilizing creativity). The data from Table 4 shows that the experimental class achieved a mean score of 19.4091 with a standard deviation of 8.84070 in DT-6, demonstrating that the integration of the scientific approach in PBL can substantially enhance students' design thinking abilities.

Design thinking is a creative, user-centered process focused on solving complex problems by understanding user needs and generating innovative solutions. The scientific approach within PBL promotes this process by engaging students in systematic inquiry. Students begin by observing problems, formulating hypotheses, gathering data, analyzing information, and drawing conclusions. In design thinking, this mirrors the process of identifying user needs and problem areas, collecting insights from multiple perspectives, and developing user-centered solutions. The structured nature of the scientific approach aligns well with the iterative process of design thinking, where students ideate, prototype, and test solutions continuously, refining them based on feedback and results.

This study's findings are in line with previous research demonstrating that the integration of the scientific approach within PBL can significantly improve students' design thinking skills (Utomo et al., 2022; Lufri et al., 2020; Sufri & Pasaribu, 2022). The scientific method's structured steps—such as observation, hypothesis formulation, and experimentation—provide students with a clear process for addressing complex, real-world problems. This structure is essential for design thinking, as it encourages students to systematically explore solutions while remaining flexible and creative. As they engage in these processes, students develop the ability to balance analytical thinking with creative problem-solving.

Furthermore, the integration of the scientific approach in PBL fosters a deeper level of collaboration and communication among students, both of which are crucial elements of design thinking (Utomo et al., 2022). In PBL, students work in teams to tackle real-world problems, learning to exchange ideas, give and receive constructive feedback, and utilize the diverse expertise of their peers. This collaborative environment strengthens their ability to approach problems from various angles and encourages them to incorporate diverse perspectives into their solutions. By working together through the scientific process, students not only enhance their analytical skills but also develop the interpersonal and communication abilities necessary for effective collaboration in real-world settings.

The iterative nature of design thinking is also reinforced by the scientific approach. As students ideate, prototype, and test their solutions, they engage in a cyclical process of learning and improvement. This iterative process is a hallmark of design thinking, encouraging students to view failure as an opportunity to learn and refine their ideas. The scientific approach, with its emphasis on experimentation and data-driven conclusions, complements this cycle, providing students with a structured yet flexible framework for creative exploration.

Additionally, the scientific approach in PBL promotes metacognitive awareness, enabling students to reflect on their learning processes and think critically about their strategies. This reflection helps students become more aware of how they approach problem-solving, which is vital for developing design thinking competencies. By understanding their thought processes, students can better regulate their actions, adapt their strategies, and enhance their ability to generate creative and innovative solutions.

In conclusion, while the conventional learning model demonstrated strengths in fostering human-centeredness (DT-2) and collaboration with diverse perspectives (DT-4), the integration of the scientific approach within PBL proved to be more effective in enhancing overall design thinking skills. The experimental class outperformed the control class in key dimensions such as comfort with uncertainty and risk (DT-1), attention to the process and its impact on others (DT-3), learning orientation through creation and testing (DT-5), and confidence and optimism in utilizing creativity (DT-6). These findings highlight the value of combining the scientific approach with PBL to cultivate students' design thinking abilities, preparing them to tackle complex real-world challenges with creativity, innovation, and collaborative problem-solving skills.

CONCLUSION

This study demonstrates that integrating the scientific approach within the problem-based learning (PBL) model significantly enhances students' creative thinking and design thinking skills, particularly in physics education. The findings reveal that students in the experimental class, who were exposed to the PBL model with the scientific approach, outperformed those in the control class in various dimensions of creative and design thinking, such as comfort with uncertainty, collaboration, and innovation. The structured nature of the scientific approach, combined with the real-world problem-solving elements of PBL, fosters an environment where students can explore ideas, collaborate effectively, and apply systematic methods to generate innovative solutions.

The integration of the scientific approach in PBL not only improves students' cognitive abilities but also strengthens essential social and emotional skills such as teamwork, communication, and resilience. These skills are critical for success in the 21st century, where adaptability, creativity, and problem-solving are highly valued. The study provides strong evidence that adopting this combined educational approach can better prepare students to meet future challenges by developing both their intellectual and interpersonal competencies.

RECOMMENDATION

Given the positive outcomes observed in this study, it is recommended that educators and policymakers consider incorporating the scientific approach within the PBL model in curricula, particularly for complex subjects like physics. This teaching method should be further explored in various educational settings to assess its broader impact on student learning outcomes. Additionally, teacher training programs should be developed to equip educators with the necessary skills to implement this integrated approach effectively.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to all participants involved in this study. We also extend our appreciation to the teachers and colleagues who provided valuable support and feedback throughout the research process. Special thanks to those who contributed to the data collection and analysis, helping to make this study possible.

REFERENCES

Aka, K. A., & Mukmin, B. A. (2020). Worksheet Performance Evaluation Oriented Scientific Approach. *Universal Journal of Educational Research*. https://doi.org/10.13189/ujer.2020.080610

Akbar, R., Sukmawati, U. S., & Katsirin, K. (2024). Analisis Data Penelitian Kuantitatif. *Jurnal Pelita Nusantara*. https://doi.org/10.59996/jurnalpelitanusantara.v1i3.350

Azizah, D., Cahyani, M. D., & Nurdiyanti, D. (2022). The Implementation of Student Worksheets with Scientific Approach on Reduction Oxidation Reaction Matter to Students' Cognitive Learning Outcome. *Jurnal Pendidikan Sains Indonesia*. https://doi.org/10.24815/jpsi.v10i1.20349

Azizahwati, A., Januarti, J., Sari, S. W., Sari, R. A., Ranti, L., & Septyowaty, R. (2023). Meta analysis of the effect of STEM application on higher order thinking skill in science learning. *Momentum: Physics Education Journal*. https://doi.org/10.21067/mpej.v7i1.7959

Chairuddin, C., & Farman, F. (2019). Comparison of The Effectiveness of Scientific Approach and Problem-Solving Approach in Problem-Based Learning in Class IX of SMP Negeri 3 Pangsid. *Journal of Mathematics Education*. https://doi.org/10.31327/jomedu.v4i2.1010

Demir, B. K., & Isleyen, T. (2015). The effects of argumentation based science learning approach on creative thinking skills of students. *Educational Research Quarterly*.

Demir-Kaçan, S., & Şahin, F. (2018). The Impact of Scientific Creative Thinking Skills on Scientific Process Skills. *SHS Web of Conferences*. https://doi.org/10.1051/shsconf/20184801060

Dewi, S., Mariam, S., & Kelana, J. B. (2019). Meningkatkan Kemampuan Berpikir Kreatif Ipa Siswa Sekolah Dasar Menggunakan Model Contexual Teaching and Learning. *JP2SD (Jurnal Pemikiran Dan Pengembangan Sekolah Dasar)*.

Dilekçi, A., & Karatay, H. (2023). The effects of the 21st century skills curriculum on the development of students' creative thinking skills. *Thinking Skills and Creativity*. https://doi.org/10.1016/j.tsc.2022.101229

Florida, R., Mellander, C., & King, K. (2015). THE GLOBAL CREATIVITY INDEX 2015.

In *Martin Prospery Institute*.

Hermawan, H., Mahardika, F., Darmayanti, I., Sumantri, R. B. B., Saputra, D. I. S., & Aminuddin, A. (2023). New Media as a Tools to Improve Creative Thinking: A Systematic Literature Review. *Proceedings - 2023 IEEE 7th International Conference on Information Technology, Information Systems and Electrical Engineering, ICITISEE 2023*. https://doi.org/10.1109/ICITISEE58992.2023.10404556

Hidayati, A. U., & Retnawati, H. (2016). Effectiveness Problem Based Learning And Scientific Approach To Improve Higher Order Thinking Skills. *Proceeding of 3rd International Conference on Research Implementation and Education of Mathematics Education*.

Jelita*, J., & Nuraida, N. (2023). The Effect of a Scientific Approach Based on Problem Based Learning Models on Students Science Problem Solving Skills at Madrasah Ibtidaiyah. *Jurnal Pendidikan Sains Indonesia*. https://doi.org/10.24815/jpsi.v11i4.31734

Klutse, G. Y. (2021). A Novel Approach to Integrated Science Teaching and Learning in a Selected Ghanaian Junior High School. *The European Educational Researcher*. https://doi.org/10.31757/euer.411

Lufri, L., Laili, F., & Anhar, A. (2020). Effect of Active Learning in Form of Scientific Approach with Assistance of Student Worksheets Based Problem Based Learning (PBL) Towards Students Biology Psychomotor Competence in Bacterial Material. *Journal of Educational Sciences*. https://doi.org/10.31258/jes.4.1.p.20-29

Maharani, R., Marsigit, M., & Wijaya, A. (2020). Collaborative learning with scientific approach and multiple intelligence: Its impact toward math learning achievement. *Journal of Educational Research*. https://doi.org/10.1080/00220671.2020.1806196

Manda, T. G., & Marsigit, M. (2021). Efektivitas Implementasi Pendekatan Scientific dengan Model Problem Based Learning dan Learning Cycle 5E. *Jurnal Eksakta Pendidikan (JEP)*. https://doi.org/10.24036/jep/vol5-iss2/607

Masitoh, L. F., & Prasetyawan, E. (2020). The Effectiveness Of Scientific Approach With Open-Ended Problem Based Learning Worksheet Viewed From Learning Achievement, Creative Thinking Ability, Interest, And Mathematics Self-Efficacy. *Daya Matematis: Jurnal Inovasi Pendidikan Matematika*. https://doi.org/10.26858/jds.v7i3.11874

Rahuma, A., & Ananda, A. (2019). The effect of using cooperative learning model type of examples non examples and motivation toward student learning outcomes. *JPPI (Jurnal Penelitian Pendidikan Indonesia)*. https://doi.org/10.29210/02018275

Rösch, N., Tiberius, V., & Kraus, S. (2023). Design thinking for innovation: context factors, process, and outcomes. *European Journal of Innovation Management*. https://doi.org/10.1108/EJIM-03-2022-0164

Sirotová, M., Michvocíková, V., & Rubacha, K. M. (2021). Quasi-experiment in the educational reality. *Journal of Education Culture and Society*. https://doi.org/10.15503/jecs2021.1.189.201

Sufri, S., & Pasaribu, F. T. (2022). Development of Calculus Teaching Materials through Problem-Based Learning Model and Scientific Approach. *Budapest*

International Research and Critics.
Sugiyono. (2013). Metode Penelitian Kualitatif, Kualitatif R & D. In *Bandung: Alfabeta*.
Suprihatin, D., Winarni, R., Saddhono, K., & Wardani, N. E. (2023). The Influence of Indonesian Instructional Books with a Scientific Approach on Students' Learning Outcomes in Scientific Writing. *International Journal of Instruction*. https://doi.org/10.29333/iji.2023.16230a
Sutisna, I. (2020). Teknik Analisis Data Penelitian Kuantitatif. *Statiska Penelitian*.
Syahrin, A., Dawud, Suwignyo, H., & Priyatni, E. T. (2019). Creative thinking patterns in student's scientific works. *Eurasian Journal of Educational Research*. https://doi.org/10.14689/ejer.2019.81.2
Syaifuddin, M. (2017). Increasing problem solving competence through problem-based learning model and scientific approach. *Pertanika Journal of Social Sciences and Humanities*.
Tarigan, B. (2021). Scientific approach in physical education: Improving creativity and physical fitness of senior high school students in mountainous areas. *International Journal of Human Movement and Sports Sciences*. https://doi.org/10.13189/saj.2021.091313
Utomo, S. W., Joyoatmojo, S., Yutmini, S., & Suryani, N. (2022). Problem-based learning model with a scientific approach to improve higher order thinking skills. *International Journal of Learning and Change*. https://doi.org/10.1504/ijlc.2022.119515
Wagner, G., Prester, J., & Schryen, G. (2021). Exploring the scientific impact of information systems design science research. *Communications of the Association for Information Systems*. https://doi.org/10.17705/1CAIS.04837
Zainudin, M., & Istiyono, E. (2019). Scientific approach to promote response fluency viewed from social intelligence: Is it effective? *European Journal of Educational Research*. https://doi.org/10.12973/eu-jer.8.3.801
Zulfah, Z., Astuti, A., Ezaldi, D., Firmansyah, E. H., Risali, H., Suryani, L., Putri, M. F., Aristi, R., & Rahmadani, Y. (2022). Meta Analisis: High Order Thinking Skills. *Journal on Education*. https://doi.org/10.31004/joe.v4i3.501