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Impact of Blended Learning on Students' Creative Thinking Skills in Wave and Optics Course

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Abstract

Creative thinking skills are essential competencies that students must develop, particularly in physics education, which involves problem-solving and the application of complex concepts. One effective method for enhancing these skills is blended learning, which combines both face-to-face and online learning. This study aims to examine the impact of blended learning on the creative thinking skills of students in the Basic Physics course, specifically in the topics of Waves and Optics. The research used a quasi-experimental design with a pre-test and post-test approach, involving 20 first-semester students selected through purposive sampling. Data analysis was conducted using the N-gain formula by Hake to measure improvements in students' creative thinking skills, which included indicators of fluency, flexibility, originality, elaboration, and sensitivity to problems. The results showed a significant improvement in students' creative thinking skills, with an average pre-test score of 44.65 and a post-test score of 84.25, yielding an N-gain of 70.56%, which falls into the high category. Based on these findings, it can be concluded that blended learning is effective in enhancing students' creative thinking skills, particularly in the context of basic physics education. The implementation of blended learning positively contributes to the development of students' creativity through a combination of face-to-face and online learning.

Keywords: Blended learning; Creative thinking skills; Basic physics; Waves and optics.

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INTRODUCTION

Higher education faces significant challenges in aligning teaching methods with technological advancements and the demands of the 21st century. One of the main challenges is equipping students with creative thinking skills necessary for addressing real-world complex problems (Smith & Brown, 2021; Wahyuni et al., 2023; Zhang et al., 2024). The Wave and Optics course, a fundamental part of physics curricula, provides a rich context for fostering creative thinking through the exploration of scientific phenomena (Johnson, 2022; Aini et al., 2024; Ramli et al., 2020). However, conventional teaching methods often fall short in promoting interactive and reflective learning experiences, which are essential for developing these skills (Zhang et al., 2024; Wahyuni et al., 2023). Hence, there is a pressing need for innovative approaches that integrate technology and pedagogy to enhance students' creative thinking abilities.

Blended learning, an increasingly popular approach in higher education, combines face-to-face instruction with online learning components (Garrison & Vaughan, 2021; Rahmawati et al., 2022; Nami et al., 2023). This approach facilitates flexible and diverse interactions between students and instructors while providing access to an array of digital learning resources (Smith & Brown, 2021; Rahmawati et al., 2022). In the context of the Wave and Optics course, blended learning can support conceptual understanding through simulations, experimental videos, and collaborative online discussions (Garrison & Vaughan, 2021; Nami et al., 2023). Furthermore, blended learning fosters student-centered learning, a critical principle for nurturing creativity (Zhang et al., 2024; Wahyuni et al., 2023).

Creative thinking is a vital competency in the era of the Fourth Industrial Revolution (Robinson et al., 2021; Wahyuni et al., 2023; Johnson, 2022). It involves generating novel ideas, connecting disparate concepts, and devising innovative solutions to complex problems (Smith & Brown, 2021; Ramli et al., 2020). In the Wave and Optics course, creativity manifests in solving physics problems such as interference, diffraction, and light polarization (Aini et al., 2024; Johnson, 2022; Nami et al., 2023). Blended learning provides an environment conducive to fostering such creativity by integrating immersive physical and digital experiences (Robinson et al., 2021; Rahmawati et al., 2022). However, further research is needed to understand how blended learning influences the development of students' creative thinking skills in this specific context.

Previous studies suggest that blended learning has substantial potential to enhance creative thinking skills across disciplines (Smith & Brown, 2021; Wahyuni et al., 2023; Nami et al., 2023). In physics education, this approach can offer dynamic and diverse learning experiences, such as digital simulations and collaborative experimental data analysis (Johnson, 2022; Ramli et al., 2020; Aini et al., 2024). For example, computer simulations of wave phenomena can help students intuitively grasp complex concepts (Rahmawati et al., 2022; Zhang et al., 2024). Additionally, blended learning allows students to learn at their own pace, a factor that enhances their ability to process and develop creative ideas (Smith & Brown, 2021; Nami et al., 2023).

Despite its advantages, implementing blended learning in the Wave and Optics course poses several challenges (Robinson et al., 2021; Rahmawati et al., 2022; Zhang et al., 2024). One major challenge is designing instructional materials suited to this model, including the development of digital modules and guidelines for collaborative activities (Garrison & Vaughan, 2021; Wahyuni et al., 2023). Additionally, both instructors and students need adequate technological skills to optimize the potential of blended learning (Smith & Brown, 2021; Ramli et al., 2020). Without sufficient support, the adoption of blended learning may become ineffective or even counterproductive in fostering students' creative thinking (Nami et al., 2023; Rahmawati et al., 2022).

Research on the impact of blended learning on creative thinking remains relatively new, particularly in the context of higher education in Indonesia (Wahyuni et al., 2023; Ramli et al., 2020; Nami et al., 2023). Most previous studies have focused on the cognitive aspects of learning, such as conceptual understanding or general learning outcomes (Smith & Brown, 2021; Robinson et al., 2021). However, the potential of blended learning to enhance affective and psychomotor aspects, including creativity, warrants further exploration (Johnson, 2022; Aini et al., 2024). Research on the Wave and Optics course can make significant contributions by elucidating how blended learning can achieve these objectives (Robinson et al., 2021; Wahyuni et al., 2023).

This study aims to explore the impact of blended learning on students' creative thinking skills in the Wave and Optics course. Specifically, it seeks to analyze how this approach supports the development of creative ideas through structured and interactive learning activities (Zhang et al., 2024; Nami et al., 2023; Rahmawati et al., 2022). Furthermore, the study will identify challenges and opportunities encountered during the implementation of blended learning in this context (Smith & Brown, 2021; Wahyuni et al., 2023). Thus, it is expected to provide new insights for educators and curriculum developers in designing more innovative and effective learning approaches (Robinson et al., 2021; Johnson, 2022).

In summary, blended learning has immense potential to enhance students' creative thinking skills, particularly in the context of the Wave and Optics course. However, its implementation requires careful planning, including the design of teaching strategies that effectively integrate technology and collaborative activities. This research is anticipated to contribute significantly to understanding the influence of blended learning on fostering students' creativity while addressing the challenges of designing innovative learning in the digital era. Consequently, the findings of this study could serve as a reference for educators and policymakers in developing more relevant and impactful teaching approaches for higher education.

Novelty of the study

This study offers a novel perspective by focusing on the integration of blended learning in fostering creative thinking skills, specifically within the context of the Wave and Optics course in higher education. While previous research predominantly examines the cognitive benefits of blended learning, such as enhanced concept comprehension and general learning outcomes, this study delves into its impact on the development of creativity—a critical skill in the 21st century. By emphasizing creative problem-solving through innovative pedagogical methods, this research addresses an existing gap in the literature, especially in the realm of physics education. Furthermore, the exploration of digital simulations, collaborative discussions, and student-centered learning activities tailored to complex physical phenomena, such as interference and diffraction, establishes a unique contribution to both educational theory and practice.

Another distinctive aspect of this study is its contextual focus on Indonesian higher education, where research on the application of blended learning to creative skill development remains limited. The investigation not only evaluates the efficacy of this approach in a specific academic setting but also identifies the challenges and opportunities that arise during its implementation. By integrating insights from global research with localized applications, the study provides a dual contribution: advancing the theoretical understanding of blended learning's potential and offering practical guidance for educators and curriculum developers. Ultimately, the findings aim to inform innovative instructional designs that align with the digital transformation in education and the growing demand for creative competencies in the workforce.

METHOD

This study employed a quasi-experimental design with a one-group pretest-posttest approach. This design was chosen to evaluate the impact of blended learning on students' creative thinking skills by comparing pretest and posttest results within the same group. The experimental group underwent blended learning-based instruction in the Wave and Optics subject. The participants consisted of first-semester students from the physics education program – Mataram

University, selected through purposive sampling. The inclusion criteria required that students had completed an introductory physics course as a prerequisite. The total sample size was 20 students, deemed sufficient to provide preliminary insights into the effects of blended learning on creative thinking skills.

Preparation

The study was carried out in three main stages: preparation, implementation, and data processing. The preparation stage involved the development of blended learning instructional materials and instruments to assess creative thinking skills. The instructional materials included digital modules, online assignments, and guidelines for collaborative discussions, designed to facilitate student engagement and conceptual understanding. These resources were tailored to the specific learning objectives of the Wave and Optics course, emphasizing interactive and reflective learning activities. Additionally, the creative thinking skills test, comprising pretest and posttest items, was carefully designed and validated by subject matter experts to ensure reliability and alignment with the study's goals.

Implementation

During the implementation stage, the intervention was conducted over six sessions, each integrating face-to-face and online components to create a cohesive blended learning environment. Before the intervention began, students took a pretest to measure their baseline creative thinking skills. This assessment served as a benchmark to evaluate the subsequent impact of the blended learning activities.

Each session was structured to balance direct instruction, digital resources, and collaborative discussions. The face-to-face meetings focused on core physics concepts, allowing students to explore topics such as wave interference and diffraction through hands-on activities and instructor-led demonstrations. These sessions were complemented by digital learning resources, including simulations, video demonstrations, and problem-solving exercises available on an online platform. Collaborative discussions, facilitated through virtual forums, encouraged students to exchange ideas, pose questions, and propose solutions to complex problems, fostering critical and creative thinking.

At the conclusion of the six-session intervention, a posttest was administered to assess the improvement in students' creative thinking skills. The combination of face-to-face and digital learning components was designed to offer a comprehensive learning experience that integrated theoretical understanding with practical application, aiming to stimulate creativity and deepen conceptual knowledge.

Data processing

The data processing stage involved analyzing the pretest and posttest results using the normalized gain (N-gain) formula proposed by Hake (1998).

$$N - gain = \frac{Posttest - Pretest}{100 - Posttest}$$

This method provided a quantitative measure of the effectiveness of the blended learning approach. N-gain scores were categorized into three levels: high

($g > 0.7$), medium ($0.3 \leq g \leq 0.7$), and low ($g < 0.3$) (Hake, 2020). These categories helped to interpret the degree of improvement in students' creative thinking skills following the intervention.

In addition to the pretest and posttest results, classroom observations were conducted during the intervention to monitor student engagement in blended learning activities. These observations focused on students' participation in discussions, responsiveness to digital resources, and collaborative problem-solving efforts. The qualitative insights gained from these observations provided a broader understanding of how the blended learning approach influenced students' learning processes and creative skill development.

Analytical framework

The combination of quantitative and qualitative data analyses enabled a comprehensive evaluation of the intervention's impact. The quantitative analysis of N-gain scores highlighted the degree of improvement in creative thinking skills, while the qualitative observations offered insights into factors that supported or hindered the development of creativity. Specifically, the observations helped identify patterns in student engagement, such as the extent of collaboration in discussions, the ability to utilize digital resources effectively, and the integration of theoretical knowledge with practical applications.

Challenges and limitations

Although this study provides valuable insights, it is important to acknowledge potential limitations in the research design. The one-group pretest-posttest design lacks a control group, which may limit the ability to attribute observed improvements solely to the blended learning intervention. However, this limitation is mitigated by the detailed observations and triangulation of data sources, which enhance the validity of the findings. Additionally, the relatively small sample size may restrict the generalizability of the results, but it serves as a valuable foundation for further research on this topic.

Anticipated contributions

The findings from this study are expected to provide evidence of the effectiveness of blended learning in enhancing creative thinking skills within the context of a physics education course. By examining both the quantitative outcomes and qualitative observations, this research aims to contribute to the broader understanding of how innovative teaching approaches can address the challenges of 21st-century education. Furthermore, the study seeks to offer practical recommendations for educators and curriculum developers in designing effective blended learning environments that nurture creativity and engagement.

RESULTS AND DISCUSSION

This study investigates the effect of blended learning on students' creative thinking skills, focusing specifically on the Wave and Optics matter. The analysis revealed a significant improvement in creative thinking skills, particularly in the indicators of Flexibility, Elaboration, Originality, and Sensitivity to Problems, as evidenced by high N-gain scores. These findings align with previous research, which highlights blended learning as an effective educational approach that fosters creativity by combining online and face-to-face learning environments (Garrison & Vaughan, 2020).

The results demonstrated that blended learning enhances not only overall creative thinking skills but also students' engagement in interactive learning activities. This is particularly evident in the improvement of Fluency, although it remains in the medium category, underscoring the importance of more intensive instructional design to support students' fluency in creative thinking. As noted by Hrastinski (2021), well-designed blended learning, incorporating varied and collaborative activities, can significantly enhance student engagement and creativity. The specific improvements in each indicator are illustrated in Figure 1.

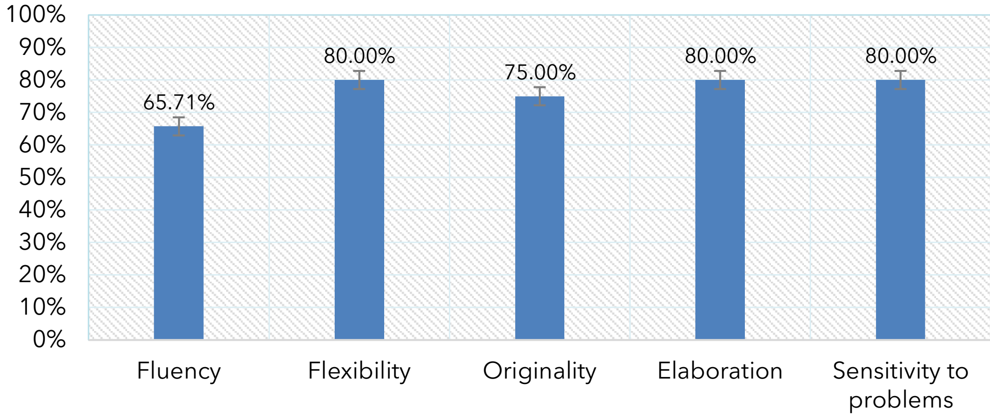

Figure 1. N-gain data on students' creative thinking skills

As depicted in Figure 1, blended learning proved effective in enhancing creative thinking skills, particularly within the Basic Physics course. Indicators such as Flexibility, Elaboration, Originality, and Sensitivity to Problems showed substantial improvement, with N-gain scores in the high category. For instance, Flexibility and Elaboration reached improvement levels of 80% and 75%, respectively. These findings are consistent with earlier studies suggesting that technology-based learning methods like blended learning encourage students to think flexibly and creatively when solving complex problems (Garrison & Vaughan, 2020).

While Fluency achieved an improvement rate of 65.71% in the medium category, this result highlights the need for further instructional innovations. Structured practice is essential to help students generate ideas more fluidly and creatively. This aligns with Harasim (2017), who emphasizes that blended learning environments should be designed to foster the exploration of ideas, thereby maximizing creative fluency. These results demonstrate that while blended learning has already made a significant impact, there is room for enhancement, particularly in fostering seamless idea generation.

Active student engagement in various blended learning activities, such as online discussions and collaborative tasks, was a key factor driving improvements in creative thinking skills. These activities not only enriched students' conceptual understanding but also strengthened their ability to elaborate and develop original ideas. According to Hrastinski (2021), integrating digital technology into blended learning allows students to engage personally and collaboratively, thereby supporting comprehensive creativity development.

The findings are further corroborated by quantitative data, as presented in Table 1, which outlines the average scores for students' creative thinking skills before and after the intervention.

Table 1. Average scores for students' creative thinking skills

Pre-test	Post-test	N-gain
44.65	84.25	70.56%

As shown in Table 1, the study revealed a significant increase in students' creative thinking skills following the blended learning intervention. The average pre-test score of 44.65 indicated a relatively low baseline level of creative thinking skills among students. However, after engaging in the blended learning approach, the average post-test score rose dramatically to 84.25. This represents an N-gain score of 70.56%, classified as high, which underscores the effectiveness of blended learning in enhancing students' abilities to elaborate and generate creative ideas.

The improvement highlights the ability of blended learning to bridge the gap between theoretical understanding and creative application, particularly in the context of the Wave and Optics. These results align with prior research demonstrating that technology-integrated learning and active interaction significantly enhance student engagement and creativity (Hrastinski, 2021).

Despite the notable overall success, the Fluency indicator showed room for further development, with an N-gain score categorized as medium. This suggests that students may require more structured opportunities to practice generating ideas rapidly and effectively. Incorporating additional creative brainstorming exercises and interactive simulations into the blended learning curriculum could address this limitation. Such strategies are supported by research emphasizing the need for diverse and exploratory learning activities to optimize creative fluency in students (Harasim, 2017).

A closer examination of the intervention revealed several factors that contributed to its success. First, the integration of digital simulations and interactive online platforms facilitated a deeper conceptual understanding, enabling students to approach problems creatively. Second, the collaborative nature of the learning activities, such as group discussions and problem-solving tasks, fostered an environment conducive to idea-sharing and innovation.

However, some challenges were also identified. The need for sufficient technological infrastructure and digital literacy among both students and instructors emerged as a critical consideration. Without adequate resources and training, the full potential of blended learning cannot be realized, potentially limiting its impact on creative skill development. These challenges underscore the importance of institutional support in ensuring the successful implementation of blended learning methodologies.

The findings of this study have broader implications for both educational practice and research. First, they highlight the transformative potential of blended learning in physics education, particularly in courses like Wave and Optics, where abstract concepts can benefit from interactive and visual learning tools. Second, the study contributes to the growing body of evidence supporting the integration of digital technology into higher education, offering valuable insights for curriculum developers and educators aiming to foster 21st-century skills.

In addition, the study underscores the need for a balanced approach to instructional design, combining structured guidance with opportunities for exploration and collaboration. By addressing these elements, blended learning can not only enhance students' creative thinking skills but also prepare them for the complex problem-solving demands of their future careers.

In summary, the results of this study demonstrate that blended learning significantly enhances creative thinking skills in the Basic Physics course, particularly in the the topics of Wave and Optics. The high N-gain scores observed across most indicators, combined with the qualitative insights into student engagement, affirm the effectiveness of this instructional approach. While challenges remain, particularly in the areas of fluency and technological infrastructure, the overall findings provide a compelling case for the adoption of blended learning as a means of fostering creativity and innovation in higher education.

By integrating face-to-face and online learning components, this study highlights the potential for blended learning to address critical educational goals, including the development of creative competencies. These findings offer a roadmap for future research and practice, paving the way for more effective and innovative approaches to teaching and learning in the digital age.

CONCLUSION

The blended learning model has a significant impact on enhancing students' creative thinking skills in the the topics of Wave and Optics. The implementation of this approach led to a substantial increase in students' average scores from pre-test to post-test, as evidenced by the high N-gain scores. These findings indicate that the integration of face-to-face and online learning not only strengthens students' conceptual understanding but also effectively develops their creative thinking abilities, which are essential in physics education.

This study highlights the potential of blended learning as an innovative pedagogical approach to bridge theoretical knowledge with creative application. By fostering interactive and reflective learning experiences, blended learning prepares students to tackle complex problems with originality and flexibility. The results underscore the importance of integrating digital resources and collaborative activities into physics education, offering valuable insights for educators aiming to enhance both engagement and creativity in their classrooms.

RECOMMENDATION

This study recommends that educators and curriculum developers adopt blended learning approaches to enhance students' creative thinking skills, particularly in science courses such as Wave and Optics. Instructional designs should integrate diverse activities, such as digital simulations, collaborative problem-solving, and reflective discussions, to stimulate creativity and engagement. Furthermore, institutions should invest in technological infrastructure and provide training for both instructors and students to optimize the effectiveness of blended learning. Future research should explore scalability and long-term impacts of this approach across broader academic settings and disciplines.

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