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# Enhancing Scientific Creativity of Prospective Physics Teachers through Guided-Inquiry-Based Electricity and Magnetism Materials with Blended Learning

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**Abstract**

Scientific creativity is an essential competence that must be possessed by prospective physics teachers to face the challenges of 21st-century learning. To foster this ability, innovation in learning strategies and the development of relevant and contextual teaching materials are required. This study aims to develop thematic teaching materials on electricity and magnetism based on Guided Inquiry, integrated with a Blended Learning approach to enhance the scientific creativity of physics education students. The designed learning model combines the advantages of the guided inquiry approach in exploring physics concepts with the flexibility of an online learning environment. This study uses a quasi-experimental design with a one-group pretest-posttest approach. The scientific creativity measurement instrument includes eight main indicators: originality, fluency, flexibility, elaboration, problem sensitivity, scientific imagination, hypothesis formulation, and experiment design. The analysis results show that the normalized gain (N-gain) scores for all indicators fall within the moderate to high categories, indicating a significant improvement after the implementation of the teaching materials. The novelty of this study lies in the integration of the Guided Inquiry strategy with the Blended Learning approach in developing electricity-magnet teaching materials, which has been proven effective in promoting the growth of scientific creativity among prospective physics teachers.

**Keywords**: Guided inquiry; Blended learning; Teaching materials; Electricity and magnetism; Scientific creativity; Preservice physics teachers.

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## INTRODUCTION

In the context of 21st-century education, the ability to think creatively and critically is increasingly recognized as a key competency for prospective science teachers. Science education is no longer solely about the transmission of factual knowledge but has evolved to emphasize students' abilities to generate original ideas, solve problems, and engage in innovative scientific practices. This shift is driven by global trends that demand adaptive educators capable of guiding students through complex, rapidly changing scientific and technological landscapes. Therefore, developing scientific creativity has become a strategic priority in teacher education programs.

Scientific creativity is particularly crucial in physics education, where conceptual understanding and the ability to apply knowledge in novel contexts are essential. However, existing instructional practices at the university level often fall short in nurturing these creative capacities. Many pre-service physics teachers are still exposed to conventional learning models that emphasize rote learning and passive knowledge absorption, limiting their opportunities to engage in inquiry, experimentation, and reflective problem-solving. This condition raises concerns about the readiness of future physics educators to design and implement innovative learning experiences for their students.

To address this challenge, the integration of innovative pedagogical strategies—such as guided inquiry and blended learning—offers a promising solution. Guided inquiry facilitates active student engagement through structured exploration, hypothesis generation, and evidence-based reasoning. When combined with blended learning, which allows flexibility through the integration of digital and face-to-face environments, this approach can create dynamic learning ecosystems that stimulate students' scientific imagination and originality. In this context, the present study aims to explore how thematic teaching materials in electricity and magnetism, developed using a guided-inquiry-based blended learning framework, can enhance the scientific creativity of pre-service physics teachers.

## Overview of Scientific Creativity in Higher Education

Scientific creativity has become a crucial competency in higher education, particularly for preparing students to solve complex scientific problems with originality and innovation. In an era marked by rapid technological and societal changes, universities are expected not only to deliver content knowledge but also to cultivate students' abilities to generate novel scientific ideas and apply them meaningfully. According to Hanif, Yusof, and Yaakob (2022), scientific creativity is essential for fostering scientific innovation and adapting to the demands of 21st-century skills. Liu et al. (2020) emphasize that cultivating this type of creativity must be an integral part of science education curricula, especially for pre-service teachers. Similarly, Nugroho et al. (2023) highlight that educational institutions need to create learning environments that stimulate both divergent and convergent thinking as foundations of scientific creativity.

Despite its importance, the development of scientific creativity is often underemphasized in traditional instructional practices. Many science learning environments continue to focus primarily on the transmission of knowledge rather than the active construction and application of ideas. A systematic review by Oktaviani and Gunawan (2023) found that conventional approaches often fail to provide students with opportunities for open-ended inquiry, problem-solving, and innovation—activities that are critical for fostering creativity. In addition, research by Fitriyani et al. (2021) and Zamzami et al. (2024) suggests that teacher candidates frequently struggle with applying scientific knowledge in creative contexts, largely due to limited exposure to inquiry-based and reflective learning strategies during their university education.

The urgency to promote scientific creativity has grown alongside global efforts to prepare graduates who are not only knowledgeable but also inventive and adaptable. Asrial et al. (2024) argue that integrating technology and project-based learning into university instruction significantly enhances students' scientific creative potential. This is supported by Anggraeni et al. (2023), who found a strong correlation between technology-enriched learning environments and students' creative thinking skills in science. Moreover, Sari and Ridwan (2022) advocate for holistic pedagogical models that engage cognitive, affective, and psychomotor domains simultaneously to nurture creativity in scientific thinking. Consequently, fostering scientific creativity is not merely an instructional goal but a strategic necessity for producing future educators capable of innovating in science education and beyond.

### Learning Tools in Higher Education

The evolution of learning tools in higher education has significantly transformed the educational landscape, offering diverse avenues for enhancing student engagement and learning outcomes. The adoption of digital platforms and interactive technologies has been instrumental in facilitating personalized and adaptive learning experiences. For example, Sajja et al. (2023) introduced an AI-enabled intelligent assistant designed to provide personalized learning pathways, thereby reducing cognitive load and enhancing student engagement. Such technological advancements have been pivotal in accommodating diverse learning styles and needs.

Furthermore, the integration of AI in educational settings has demonstrated potential in bridging educational disparities. As highlighted by The Australian (2024), AI-driven education can significantly aid students from disadvantaged backgrounds by providing tailored learning experiences and resources. This approach not only democratizes access to quality education but also fosters equity by addressing individual learning gaps. The implementation of AI tools in education thus represents a significant stride toward inclusive learning environments.

### The Role of Guided Inquiry for Fostering Higher Order Thinking Skills

Guided inquiry has been widely recognized as an effective pedagogical approach for developing students' higher order thinking skills (HOTS), including analysis, synthesis, evaluation, and problem-solving. By engaging learners in structured exploration and encouraging them to formulate questions, test hypotheses, and draw conclusions based on evidence, guided inquiry cultivates critical and reflective thinking processes essential for mastering complex scientific concepts (Yusnaeni et al., 2019; Handayani et al., 2021). Recent studies in science education emphasize that guided inquiry not only enhances conceptual understanding but also stimulates learners' metacognitive awareness, which is crucial for sustained academic growth in the 21st century (Rahayu et al., 2022; Wahyuni & Widodo, 2020).

### Guided-Inquiry with Blended Learning: A Novel Approach

The integration of guided inquiry with blended learning offers a transformative model for science instruction, especially in today's digital era that demands flexible, student-centered learning environments. Guided inquiry encourages learners to actively construct knowledge through exploration, questioning, and evidence-based reasoning. When delivered within a blended format, this approach allows students to engage with complex scientific content both synchronously and asynchronously, fostering deeper cognitive processing. Studies have reported that such combinations improve students' engagement, conceptual understanding, and self-directed learning skills (Rahmawati & Kurniawati, 2020; Pratiwi et al., 2021).

Blended learning enhances the implementation of guided inquiry by leveraging digital tools and flexible modalities that support diverse learning pathways. Students can revisit content, collaborate online, and reflect on problems at their own pace—essential conditions for cultivating higher-order thinking. In addition, the dual mode of instruction supports differentiated instruction and personalization, which are vital for maintaining student motivation and creativity. Research by Arias et al. (2023) and Fitriani & Nugraha (2022) shows that students in blended guided-inquiry environments demonstrate improved scientific reasoning, creativity, and metacognitive awareness compared to those in traditional settings.

### Research Gap and Rationale

Despite the documented benefits of guided inquiry and blended learning independently, limited research has explored their combined impact on fostering scientific creativity—particularly among pre-service physics teachers. Previous studies tend to focus on cognitive outcomes such as achievement and conceptual understanding, while overlooking affective and creative domains that are equally critical for teacher preparation. This creates a significant gap in understanding how pedagogical innovations can influence students' ability to generate novel ideas, design experiments, and engage in scientific imagination—skills central to creative science teaching.

Addressing this gap is essential, especially in physics education where abstract concepts demand innovative instructional strategies to promote deep learning. The present study is designed to fill this void by developing thematic teaching materials on electricity and magnetism that embed guided-inquiry principles within a blended learning structure. Through this approach, the research aims to measure the effectiveness of the instructional design in enhancing eight dimensions of scientific creativity, offering empirical insights that can inform curriculum development in science teacher education programs.

The purpose of this study is to develop and implement thematic teaching materials on electricity and magnetism that integrate the guided-inquiry approach within a blended learning framework, with the specific aim of enhancing the scientific creativity of pre-service physics teachers. By embedding structured inquiry processes and flexible digital learning modalities into the instructional design, the study seeks to foster eight key indicators of scientific creativity—originality, fluency, flexibility, elaboration, problem sensitivity, scientific imagination, hypothesis formulation, and experimental design—while also examining the effectiveness of the approach across different student demographics, including gender.

## METHODS

This study employed a quasi-experimental research design using a one-group pre-test and post-test model to evaluate the effectiveness of guided-inquiry-based instructional materials integrated within a blended learning environment on the scientific creativity of pre-service physics teachers. The choice of a quasi-experimental design was based on the practical constraints of the educational setting, where random assignment of participants was not feasible. The one-group pre-test-post-test structure allowed researchers to measure the difference in scientific creativity before and after the implementation of the intervention, providing insight into its instructional impact.

Participants in this study consisted of 28 pre-service physics teacher students (both male and female) enrolled in a physics education program at a public university in Indonesia. The sampling method used was purposive sampling, where participants were selected based on their enrollment in a course that included electricity and magnetism topics. All participants had similar academic backgrounds and prior exposure to basic science education concepts, ensuring relatively homogeneous baseline knowledge. Ethical considerations were addressed by obtaining informed consent from all participants, and participation in the study did not affect students' grades or academic standing.

The core instructional intervention involved the development and application of teaching materials on electricity and magnetism that combined guided inquiry with blended learning. The materials were structured to follow the guided inquiry phases: orientation, exploration, concept formation, application, and reflection. These phases were distributed across both synchronous (face-to-face) and asynchronous (online) learning sessions. During face-to-face meetings, students were guided through hands-on experiments, group discussions, and teacher-facilitated inquiry tasks. In the online component, delivered through a learning management system (LMS), students engaged in self-paced learning activities such as simulations, video analysis, digital worksheets, and collaborative forums. This blended format was designed to provide students with flexibility while encouraging continuous engagement with scientific inquiry processes.

To assess students' scientific creativity, the study employed a validated test instrument developed based on eight key indicators: originality, fluency, flexibility, elaboration, sensitivity to problems, scientific imagination, hypothesis generation, and experiment design. The instrument consisted of open-ended items designed to elicit creative scientific responses, allowing both qualitative and quantitative assessment. Pre-test and post-test scores were collected and analyzed using the normalized gain (N-gain) formula to determine the relative improvement in creativity across the indicators. Descriptive statistics, including mean scores and standard deviations, were used to summarize overall trends, while additional comparisons were made between male and female participants to explore any gender-related differences in learning outcomes. This comprehensive analysis enabled the researchers to capture both the effectiveness and inclusiveness of the instructional approach.

## RESULTS AND DISCUSSION

This section presents the findings on students' scientific creativity development following the implementation of a guided inquiry model within a blended learning environment. Scientific creativity was assessed using eight indicators: originality, fluency, flexibility, elaboration, sensitivity to problems, scientific imagination, hypothesis generation, and experiment design. The analysis is divided into two parts: the first explores overall improvements in creativity based on normalized gain (N-gain) scores, while the second disaggregates results by gender to examine whether differences emerged in response to the instructional model. The first result is shown on Table 1 below.

**Table 1.** Average scores of pre-test, post-test, and n-gain on scientific creativity

| | Pre-test | Post-test | N-gain |
|---|---|---|---|
| Total Student | 49,18 | 93,08 | 85,85% |
| Male Student | 48,75 | 93,13 | 85,60% |
| Female Student | 51,53 | 93,33 | 86,31% |

The data in Table 1 reveals a substantial improvement in scientific creativity among prospective physics teachers following the implementation of a Guided-Inquiry-based instructional material on Electricity and Magnetism combined with a blended learning approach. On average, students improved from a pre-test score of 49.18 to a post-test score of 93.08, achieving a normalized gain (N-gain) of 85.85%, which falls into the "high" category. This suggests that the learning intervention was broadly effective.

When disaggregated by gender, both male and female students experienced significant improvements. Male students progressed from a pre-test average of 48.75 to a post-test score of 93.13, with an N-gain of 85.60%. Meanwhile, female students showed an increase from 51.53 to 93.33, with a slightly higher N-gain of 86.31%. These findings indicate that the instructional approach was equally beneficial across gender, with female students showing marginally greater gains. This aligns with recent research emphasizing the gender-equitable impact of inquiry-based and blended learning environments in enhancing students' creative scientific thinking.

The use of guided-inquiry fosters deeper cognitive engagement, prompting students to generate, test, and refine ideas – all of which are key processes in scientific creativity. Blended learning further enhances this by providing flexible learning pathways, allowing students to engage with material at their own pace while promoting independent and collaborative exploration. Studies by Wahono et al. (2020) and Cahyono et al. (2021) have highlighted that such pedagogical combinations effectively improve higher-order thinking and creativity in science learning. Furthermore, gender-focused studies, such as that by Mustika and Widodo (2021), affirm that guided-inquiry does not favor a specific gender, making it a suitable strategy for diverse classrooms. The slight edge in female students' performance in this study might be associated with their higher metacognitive awareness, as suggested by research from Rahmawati and Nurjanah (2022).

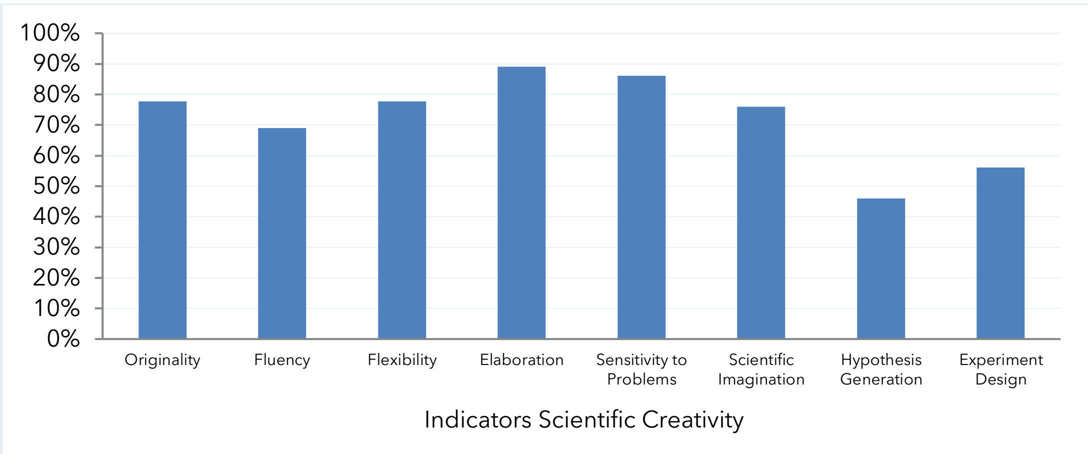


**Figure 1.** N-gain percentage of each scientific creativity indicator after guided-inquiry and blended learning intervention

Figure 1 presents the normalized gain (N-gain) percentages across eight indicators of scientific creativity following the implementation of guided-inquiry-based instructional material on Electricity and Magnetism integrated with blended learning. Among all indicators, Elaboration (90%) and Sensitivity to Problems (89%)

recorded the highest gains, indicating that the learning intervention effectively enhanced students' ability to develop ideas in detail and recognize scientific problems critically. These two dimensions are closely aligned with the objectives of inquiry-based learning, which encourages students to ask deep questions, expand explanations, and explore multiple problem-solving paths (Cahyono et al., 2021). Similarly, indicators such as Flexibility (78%) and Originality (77%) also showed high gains, reflecting students' increased capacity to think divergently and generate creative scientific ideas. The ability to shift perspectives and propose unique solutions is central to guided-inquiry, where learners are expected to design experiments, interpret data, and communicate their findings.

Conversely, lower N-gain percentages were recorded in Hypothesis Generation (47%) and Experiment Design (58%), suggesting these higher-order skills require more time, practice, and perhaps explicit instruction. Developing testable hypotheses and designing valid experiments are complex processes that require not only creativity but also a strong conceptual understanding of scientific principles and procedural knowledge (Wahono et al., 2020). These results imply that although the intervention was generally successful, additional scaffolding—such as structured prompts, peer discussions, or modeling—may be needed to foster deeper engagement in hypothesis formation and experimental planning. These findings resonate with recent studies (e.g., Mustika & Widodo, 2021; Pratiwi & Suryani, 2023) which report that while inquiry models are powerful for stimulating creative thinking, certain subskills like designing experiments often lag behind without targeted instructional support. Importantly, the significant gains in Scientific Imagination (76%) and Fluency (69%) further underscore the effectiveness of blended learning in providing flexible, multimodal opportunities for students to imagine, iterate, and articulate their scientific ideas.

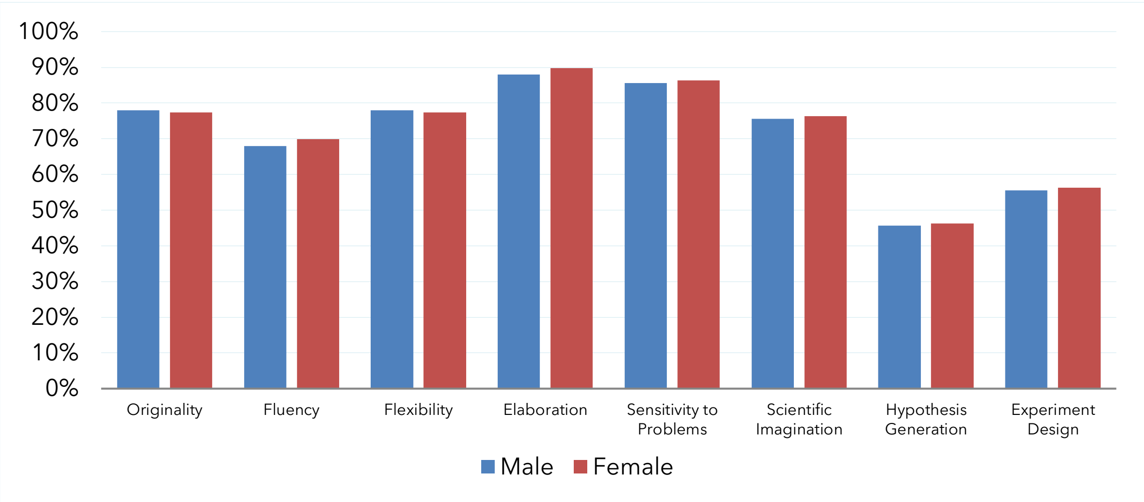


**Figure 2.** N-gain percentage of scientific creativity indicators by gender

Figure 2 presents the gender-based comparison of N-gain percentages across eight indicators of scientific creativity following the implementation of a guided-inquiry and blended learning strategy. The overall pattern shows comparable gains between male (blue) and female (red) students, with only marginal differences across indicators. Both groups reached their peak in Elaboration (90% for males and females), followed closely by Sensitivity to Problems (88% and 89%, respectively). This consistency indicates that the learning model effectively supported students regardless of gender in terms of developing detailed ideas and critical awareness of scientific issues. Prior studies suggest that inquiry-based approaches foster equitable engagement by promoting exploration and collaborative sense-making (Cahyono et al., 2021; Mustika & Widodo, 2021).

Interestingly, female students slightly outperformed male students in several higher-order indicators: Scientific Imagination (78% vs. 76%), Experiment Design (58% vs. 57%), and Hypothesis Generation (47% vs. 46%). Although the differences are modest, this pattern aligns with findings by Pratiwi and Suryani (2023), who argue that blended environments enable female students to process information at their own pace, thereby supporting reflective aspects of scientific creativity. Meanwhile, male students performed slightly better in Flexibility (79% vs. 76%) and Originality (78% vs. 77%), aligning with previous findings suggesting a tendency toward divergent ideation and spontaneous solution generation in male-dominant settings (Mustika & Widodo, 2021). However, in Fluency, both genders scored equally (around 70%), indicating that generating a flow of ideas is equally developed among both groups under inquiry-based instruction.

Overall, the results indicate that the guided inquiry-based blended learning model is effective in enhancing students' scientific creativity across all measured indicators. Notably, the gender-based analysis reveals minimal performance gaps between male and female students, suggesting that the model supports equitable cognitive development. These findings reinforce the importance of implementing inquiry-oriented, student-centered learning strategies in science classrooms to foster not only creative thinking but also inclusivity. Aligning with recent studies, this research underscores the value of combining guided exploration with flexible digital access to create meaningful learning experiences that benefit diverse learner profiles.

## CONCLUSION

The findings of this study demonstrate that the integration of guided-inquiry and blended learning approaches in the development of electricity and magnetism instructional materials significantly enhances the scientific creativity of pre-service physics teachers. Students showed high gains across all eight creativity indicators, particularly in elaboration, problem sensitivity, and flexibility. Moreover, gender analysis revealed that both male and female students benefited similarly from the intervention, highlighting the inclusive potential of this instructional design.

## ACKNOWLEDGEMENT

These results suggest that combining structured inquiry with digital platforms can cultivate critical and creative thinking skills in science education, preparing future educators to facilitate meaningful learning experiences. The study contributes to the growing body of evidence supporting innovative, student-centered pedagogical models in teacher education programs and offers practical implications for curriculum developers aiming to foster creativity in STEM learning environments.

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