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Need Analysis of Physics Laboratory Design to Enhance Student Creativity in Character Education

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Abstract: This study aims to evaluate the effectiveness of physics laboratory design in supporting the development of student creativity and character and identifying needs for improvement in the practicum context. Using a case study approach, the qualitative research method involved in-depth interviews and questionnaires with 100 Physics Education Study Programme students at Lambung Mangkurat University. The results showed that although the pre-lab activities and practicum guides received positive ratings, there were significant challenges in the relevance of the practicum to everyday life, practicum design that supports collaboration, and the development of creativity. Students felt the lab time and guidelines did not support creative and collaborative problem-solving. These findings indicate the need for a more open, problem-based laboratory design and better integration between technical aspects, creativity, and character education. This study recommends the development of laboratory modules that support problem-solving and collaborative approaches to improve students' skills holistically.

Keywords: Character education; Needs analysis; Laboratory design

Introduction

Creativity has become one of the critical 21st-century skills that is gaining increasing attention in the global education scene. The ability to think creatively and adapt to change is necessary to face complex challenges in the modern world of work and society (Ghasya & Kartono, 2022). Creativity encompasses the ability to produce novel ideas and thorough critical thinking and problem-solving abilities, facilitating a deep comprehension and application of scientific principles (Haryani et al., 2021). Prior studies indicate that incorporating creativity within the educational curriculum enhances students' skills in problem-solving and innovation (Kim et al., 2019).

Furthermore, character education is essential in developing intelligent students who embody moral values like responsibility, cooperation, and perseverance. Character education aims to instill these values as critical provisions to face challenges in the real world (Suherman et al., 2019). Integrating creativity and character education can create a holistic learning experience relevant to students' needs in the globalization era (Pitaloka, 2019). The integration of character education in formal education can improve students' interpersonal skills and professional readiness (Sukirno et al., 2023).

As one of the interactive and practical learning environments, physics laboratories have significant potential in supporting the development of students' creativity and character. Physics laboratories can

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encourage students to think critically, take initiative, and work collaboratively- all elements essential for creativity (Chan & Yuen, 2014). However, physics laboratories in Indonesia often focus on mastering technical and procedural skills without providing adequate space for developing creative skills and character. This traditional approach, which emphasizes technical procedures, may limit students' potential to develop critical and innovative thinking (Imran et al., 2023).

In addition, many physics laboratories in Indonesia need more facilities and resources in terms of equipment and space design. Laboratories are often designed for pre-determined experiments, limiting students' opportunities for independent exploration or creating their own experiments. Rigid manuals usually stifle students' creativity, and they tend to follow set procedures without developing new approaches. These limitations negatively impact the development of critical and innovative thinking skills during physics practicals. One important finding is that the traditional laboratory format, which typically reinforces concepts introduced in lectures through prescribed experiments, can limit students' creative potential. Henderson et al. (2019) argue that conventional laboratory styles can stifle innovation, suggesting that shifting towards more open experimental designs could encourage greater student engagement and creativity. This aligns with Cai et al. (2021) statement that physics education should focus on developing students' ability to think like physicists, encouraging experimental design and critical thinking skills.

An optimal physics laboratory design should focus on technical skills and provide space for developing creativity and character education. In the rapidly evolving digital era, students are required to not only master technical skills but also to think creatively and innovatively in solving problems effectively (Imran et al., 2023). Without an explicit integration between creativity, character education, and technical skills, physics laboratories risk losing the opportunity to prepare students for the challenges of the world of work and rapid technological development. Therefore, this study aims to analyze the design needs of physics laboratories that focus on technical aspects and support the development of students' creativity and character education.

Method

This research uses a qualitative method with a case study approach to analyze the design needs of physics education laboratories that can enhance student creativity in character education. The research design includes several essential stages. First, data collection was conducted through in-depth interviews with lecturers and students to identify views, experiences, and needs related to laboratory design. Secondly, questionnaires were distributed to 100 active students in the Physics Education Study Programme of Lambung Mangkurat University to collect quantitative data regarding their perceptions of laboratory design elements that support creativity and character education. Qualitative data from the interviews were analyzed using thematic analysis techniques to identify patterns and themes related to practical design elements. Quantitative data from the questionnaires were analyzed using descriptive statistics to describe students' perceptions.

Result and Discussion

Based on the results of interviews and questionnaires, pre-laboratory activities in the Physics Education Laboratory of FKIP Universitas Lambung Mangkurat are instrumental in facilitating students' understanding of physics concepts and experimental procedures. The survey results show that most students consider pre-laboratory activities to be instrumental in understanding physics concepts and practicum preparation. As many as 89% of students agreed that pre-laboratory activities were effective in deepening their understanding of concepts and theories related to practicum. In addition, 87% felt that the activities provided an opportunity to plan and prepare for the practicum well. This finding supports constructivism theory, which emphasizes the importance of preparation and early understanding in learning (Makewa, 2018). Adequate pre-lab preparation allows students to build a foundation of knowledge required before experimentation, enhancing their engagement and readiness for the practical. Although most students find pre-lab activities useful, significant challenges include limited time allocation and a lack of in-depth understanding of the initial instructions. Previous research has shown that adequate time allocation is critical for achieving optimal learning outcomes (Liu et al., 2023). Integrating relevant and in-depth pre-lab activities can help students better prepare themselves and deeply understand the experimental objectives and procedures (Marfuatun & Riandi, 2022).

The survey results of student perceptions of physics practicum activities can be seen in Table 1.

Table 1. Survey results of student perceptions of physics practicum activities

Aspects	Student Answer
Pre-Laboratory	89% of students agreed that the Pre-Laboratory activities helped them understand the concepts and theories related to the practicum.
	87% of students felt that the Pre-Laboratory activities provided an opportunity to properly plan and prepare for the practicum.
Practicum Activity Schedule	73% of students stated that the practicum schedule was based on the lecture material.
Practicum Group	78% of students agreed that the number of members in one practicum group was ideal.
Practicum Guide	78% of students stated that the lab guide provided complete, straightforward steps.
	80% of students agreed that the illustrations in the lab manual helped them understand the lab concepts.
Practical Activities and Relevance to Daily Life	39% of students felt that physics practicum activities were related to everyday problem-solving.
Verification Practicum Model	50% of students agreed that the verification practicum model is suitable for implementation in higher education.
	48% of students felt that the verification lab model provided a variety of creative activities and experiments.
	49% of students agreed that the verification lab model helped connect physics concepts with real-world phenomena.
Practicum Time	68% of students stated that the time allocated for physics practicum was adequate.
Suitability of Practical Materials	72% of students felt that the physics practicum was relevant to the material taught in related lectures.
	76% of students agreed that the physics practicum helped them understand the physics concepts taught in the course.
Role of Lecturer or Practicum Assistant	86% of students stated that the lecturer's or lab assistant's explanation was helpful in carrying out the lab.
Character and Competency Development	62% of students agreed that physics practicum helped them in character development.
	40% of students stated that the design of the physics practicum helped them work collaboratively.
	49% of students felt that the practicum design encouraged them to develop creativity in carrying out experiments.
Practicum Assessment and Evaluation	74% of students agreed that they knew the assessment components of physics practicum well.
	75% of students felt that evaluation and assessment of practicum results were carried out objectively and transparently.

Integrating real-world problems in pre-lab activities effectively increases motivation and relevance of learning (Moozeh et al., 2019). By utilizing real-world contexts in lab preparation, students can more easily relate theoretical concepts to real situations, increasing their engagement and understanding of the material. Using contextualized problems enriches the learning process by directly linking theory and practical application (Pozas et al., 2020). In addition, using conceptual questions that test students' understanding of the theory not only helps provide additional clarification where needed but also ensures that students are fully prepared to conduct the planned experiments.

Most students felt the physics practicum was relevant to the lecture material (72%) and helped them understand physics concepts (76%). This suggests that the practicum has been successful in linking theory with practice. However, there are indications that some practicals are not directly connected to the theoretical concepts learned in class, reflecting the need for further harmonization between practical materials and the lecture curriculum. Better integration between the practicum schedule and the topics being covered in class will increase the relevance and effectiveness of teaching by the experiential learning model (Saad et al., 2018). Recent research has also shown that harmonization between lecture and practicum materials can strengthen student understanding and improve skills taught in lectures (Desnita & Susanti, 2017)

73% of students stated that the practicum schedule was based on the lecture material, indicating a good synchronization between the practicum schedule and the teaching material. However, the 27% of students who felt that the schedule was not suitable indicated a potential mismatch between the practicum time and the material taught, which could hinder deep understanding. This aligns with research showing that schedule mismatches can reduce learning effectiveness and student motivation (Lusher et al., 2019). Students' assessment of the number of practicum group members was positive, with 78% feeling that the number of members was ideal. This implies that the current group structure is sufficient to support productive interactions. However, the 22% of students who disagreed indicated that there is a possibility that some groups may be too large or small, which could affect group dynamics and practicum outcomes. According to collaborative learning theory, ideal group size is important to ensure active participation and practical learning (Lee et al., 2018).

The practicum guide received positive ratings, with 78% of students considering the guide to provide clear steps and 80% finding the illustrations helpful for understanding. This suggests that the lab guide was well designed, in line with *instructional design* principles emphasizing the importance of clarity and visual support in learning materials (Ellington & Aris, 2000). Based on the interview, it was found that the lab book already contained step-by-step activities for students to follow. Laboratory practicum design should move beyond traditional 'cookbook-style' experiments, which often limit students' opportunities for creativity and critical thinking. Instead, incorporating experimental design elements into laboratory courses encourages students to evaluate techniques, solve problems, and innovate solutions (Farley et al., 2021). This not only enhances their scientific skills, but also fosters a sense of responsibility and accountability, as students must consider the implications of their experimental choices (Azis et al., 2024).

Nonetheless, updating and improving the guide to meet students' needs remains essential. Only 39% of students felt the practical activities were relevant to their daily lives. This indicates a gap between the theory learned in the laboratory and its application in a real-world context. This finding is consistent with the literature, which suggests that the relevance of practicum to real-world applications can increase student motivation and engagement (Marley et al., 2022). Better integrating real-world contexts in practical activities can improve the understanding and application of physics concepts.

50% of students stated that the verification practicumz model is suitable for implementation in higher education. In comparison, 48% felt that this model needs to provide more variety of activities. This shows that although the verification model has advantages, such as the ease of proving the theory learned, it tends to stimulate less creativity and active involvement of students in the learning process. The main drawback of the verification model is the limited space for students to develop critical thinking and problem-solving skills, as the main focus is on confirming existing concepts. There needs to be a shift from the traditional verification lab model to a more interactive and collaborative approach to enhance students' creativity and active engagement. Existing research shows that more innovative and adaptive learning models can increase student engagement, enriching their learning experience (Zulirfan et al., 2021). A more appropriate practicum model for a university environment is an inquiry-based or project-based learning model, which allows students to explore problems independently, design experiments, and collaborate in finding solutions (Wardani et al., 2019). This model enriches the learning experience and helps students develop relevant skills for the real world, such as analytical thinking, creativity, and collaboration. Lab design can significantly support students' character development, it is important to balance structure with flexibility. Too rigid a design can inhibit creativity and independence, while too much freedom can lead to confusion and frustration. Therefore, a well-considered approach that incorporates both guided and open elements is essential to maximise the educational benefits of the laboratory experience.

While 68% of students felt that the time allocated for the practicum was adequate, 32% felt insufficient. This suggests the need for further evaluation of the practical duration to ensure that all students have sufficient opportunity to complete the experiment thoroughly. Previous research has shown that adequate time is essential for optimal learning outcomes (Jez & Wassmer, 2015). Explanations from lecturers or lab assistants were rated as very helpful by 86% of students. This confirms the importance of support from teachers in the practicum process by the theory of *scaffolded instruction,* which suggests that support and guidance from teachers can improve understanding and learning success (LAM, 2019).

The survey showed that 62% of students felt practicum supported their character development. Character development in physics practicum includes integrity, responsibility, and work ethics. Practicum activities designed to promote these characteristics can improve overall learning outcomes (Derlina & Mihardi, 2015). Laboratory as a place of character education is essential in shaping students' attitudes and behavior. In the context of education, the laboratory not only functions as a space for scientific practice but also as an environment that supports student character development through various structured and directed activities. Research shows that character education can be integrated into multiple aspects of learning, including laboratory activities, which allow students to learn both cognitive and, affective, and psychomotor (Gustiranda et al., 2022; Purwanti, 2017). Practical activities in the laboratory provide opportunities for students to interact directly with the subject matter, which can increase their sense of responsibility and discipline. In physics education, students are taught to work together in groups, respect the opinions of others, and be responsible for the tasks assigned (Hariandi et al., 2023; Syafi'i et al., 2023). This aligns with research showing that a positive learning environment can significantly influence student character building (Sumiaty et al., 2022).

Meanwhile, only 40% of students felt the practicum design supported collaboration, and 49% thought it encouraged creativity. This shows that the practicum has the potential to develop collaborative skills and creativity. Still, the practicum design must be improved to support both aspects better. Student creativity needs to be enhanced by a change from the conventional practicum model to the more open Problem-Solving Laboratory (PSL) model. PSL offers a problem-based approach that allows students to work on complex real problems, requiring the application of physics concepts and collaborative problem-solving (Prahani et al., 2018; Sutarno et al., 2017). Integrating CPSL (Collaborative Problem Solving Laboratory) can further enrich the learning experience in the laboratory by combining PSL principles and collaborative methods. In CPSL, students face problems relevant to everyday life. They must work in teams with a clear division of roles, such as experimental designer, data collector, or results analyst. This approach allows students to maximize individual contributions and team collaboration and demonstrates how cooperation can solve complex problems more efficiently (Martínez-Venegas, 2022). Assessment of student character, including collaboration and creativity, should be an integral part of the evaluation system using specialized rubrics to systematically measure these soft skills. With this holistic and systematic approach, the implementation of practicum in physics laboratories is expected to better facilitate the development of technical skills and student character simultaneously.

Conclusion

Based on the results of the study, the ability of students to collaborate and be creative in physics laboratories is a category that requires improvement. Students need help collaborating and developing creativity due to limited practicum time, laboratory design that does not support independent exploration and rigid practicum guides. The current laboratory design focuses more on technical and procedural skills, with little room for activities that encourage creativity and problem-solving. Therefore, there is a need to develop laboratory designs that integrate problem-based and collaborative approaches. Laboratory modules that support problem-solving and student creativity should be developed to improve collaboration and innovation skills in physics practicum.

Author contributions

This article was compiled by a team of authors, namely S. M., S., A. S and M. W. all members of the authors completed the article together at each stage.

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Conflicts of Interest

The authors declare no conflict of interest.

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