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# Needs Analysis of the Implementation of Python-Assisted Project-Based Learning (PjBL) in Physics Education at SMAN 8 Makassar

**Riskawati [1*], Khaeruddin [2], Dirgah Kaso Sanusi [3], Nurul Mutmainnah Herman [4], Mardyanto Barumbun [5]**

[1, 2, 3, 4] Universitas Negeri Makassar, Indonesia

[5] University of Oxford, England

* riskawati@unm.ac.id

## Abstract

The urgency of this research is to identify the need for implementing Python-assisted Project-Based Learning (PjBL) to enhance students' problem-solving and computational thinking skills in physics education at SMAN 8 Makassar. This study aimed to analyze the need for implementing Python-assisted Project-Based Learning (PjBL) in physics learning at SMAN 8 Makassar. A descriptive mixed-methods design was employed involving 34 eleventh-grade students and one physics teacher. Data were collected through observations, interviews, and questionnaires and analyzed using qualitative and descriptive statistical techniques. The findings revealed that physics learning was still dominated by teacher-centered instruction with limited use of interactive technology and project-based activities. The needs analysis showed that students demonstrated a very high need for technology-based learning (91.9%), Project-Based Learning (91.6%), and the integration of Python in physics learning (92.0%). Interview results further indicated that students preferred simulations, visualizations, and project-oriented activities, while teachers expressed positive perceptions toward the implementation of Python-assisted PjBL despite limited experience in using Python for instructional purposes. In addition, the school possessed adequate facilities, including computer laboratories, internet access, and multimedia equipment, to support technology-enhanced learning. These findings provide empirical evidence that Python-assisted PjBL is highly needed and feasible to implement in secondary school physics education. The study contributes to the literature by providing a needs assessment as a foundation for developing computationally oriented physics learning and future implementation studies.

**Key Words:** *Project-Based Learning, Python, Physics Education, Needs Analysis, Technology-Based Learning.*

## Introduction

The development of digital technology in the 21st century has driven transformations across various sectors, including education. Learning is no longer focused solely on the acquisition of knowledge but is also directed toward the development of critical thinking, creativity, collaboration, communication, and digital literacy skills required in modern life and the workplace (Voogt & Roblin, 2012; Redecker, 2017). In the context of science education, particularly physics, technology integration has become one of the strategies that can help students understand abstract concepts through visualization, simulation, and interactive exploration. Numerous studies have shown that the use of digital technology in learning can enhance student engagement, facilitate active learning, and support the development of better problem-solving skills (Govender, 2025; Marín-Marín et al., 2024).

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Physics is often perceived as a difficult subject because it involves numerous abstract concepts, mathematical representations, and phenomena that are not easily observed directly. This condition contributes to low student interest and participation in the learning process. Several studies have reported that student-centered learning models supported by digital technology can improve the quality of physics education (Zulham et al., 2022). One of the most widely recommended approaches is Project-Based Learning (PjBL), as it provides students with opportunities to construct knowledge through the completion of authentic projects, while the use of the Python programming language can facilitate the visualization, simulation, and analysis of physical phenomena in a more concrete manner (Kokotsaki et al., 2016; Kurmangaliyeva et al., 2025).

Although various educational innovations have been developed, physics instruction in schools is still frequently dominated by lecture-based methods with limited use of instructional media. Such conditions result in limited student engagement and difficulties in understanding abstract physics concepts. Therefore, there is a need for a learning approach that integrates digital technology with learning activities oriented toward problem-solving and product development, one of which is the implementation of Python-assisted Project-Based Learning (PjBL) (Almulia, 2020; Govender, 2025).

Numerous studies have demonstrated that Project-Based Learning can enhance student engagement, critical thinking skills, creativity, and collaboration (Zahro & Putra, 2026). This model provides authentic learning experiences through investigative activities and project completion that are relevant to real-life situations. In science education, PjBL has also been reported to help students connect theoretical concepts with their practical applications, thereby making learning more meaningful (Kokotsaki et al., 2016; Zhang et al., 2024). Other studies indicate that the integration of PjBL with STEM approaches contributes positively to the improvement of students' critical thinking skills in physics learning (Verawati et al., 2025).

On the other hand, Python is one of the most widely used programming languages in education because of its simple syntax, ease of learning, and extensive libraries that support scientific simulations and visualizations. The use of Python in physics education enables students to explore concepts through modeling, numerical computation, and interactive graph generation (Tufino & Alemani, 2025; Kurmangaliyeva et al., 2025). In addition to improving conceptual understanding, Python contributes to the development of computational thinking, problem-solving skills, and digital literacy, which are essential competencies in the era of Industry 4.0 and Society 5.0 (Marín-Marín et al., 2024; Torres & Inga, 2025).

Although numerous studies have investigated Project-Based Learning and the use of Python in education, most have focused on examining their effectiveness in improving learning outcomes, critical thinking skills, or student motivation. Research specifically addressing the needs for implementing Python-assisted Project-Based Learning in secondary school physics education remains relatively limited. In fact, needs analysis is a crucial stage prior to the development and implementation of educational innovations to ensure their alignment with actual school conditions (Riwayani et al., 2025).

Furthermore, the successful implementation of technology-based learning is strongly influenced by students' readiness, teachers' competencies, infrastructure availability, and the characteristics of classroom learning. Therefore, studies are needed to identify the current conditions of physics learning, the challenges encountered, the need for technology-based instructional media, and the potential application of Python within the Project-Based Learning model. The results of such a needs analysis can serve as a foundation for designing more

effective educational innovations that are aligned with the school context (Redecker, 2017; Adhantoro et al., 2025).

Based on the foregoing discussion, this study aims to analyze the needs for implementing Python-assisted Project-Based Learning (PjBL) in physics education at SMAN 8 Makassar. The novelty of this study lies in its focus not only on examining the current conditions of physics learning and the need for technology integration but also on identifying the potential integration of Python within the Project-Based Learning model as a foundation for developing computationally oriented physics instruction. This study is limited to a needs analysis conducted through observations, interviews, and questionnaires involving physics teachers and eleventh-grade students of SMAN 8 Makassar as the primary sources of data.

# Method

## *Research Design*

This study employed a descriptive research method using a mixed-methods approach (quantitative and qualitative) to analyze the needs for implementing Python-assisted Project-Based Learning (PjBL) in physics education at SMAN 8 Makassar. The quantitative approach was used to collect data on students' needs through questionnaires, while the qualitative approach was employed to obtain more in-depth information through observations and interviews. This study adopted a needs assessment approach to identify the current conditions of physics learning, challenges faced by teachers and students, the need for technology-based learning, and the potential implementation of Python-assisted Project-Based Learning (PjBL).

## *Research Site and Time*

The study was conducted at SMAN 8 Makassar, located at Jalan Andi Mangerangi II Lorong 3 No. 24, Tamalate District, Makassar City, South Sulawesi, Indonesia. Data collection was carried out during the second semester of the 2025/2026 academic year, specifically in April 2026, through observations, interviews, and questionnaire administration.

## *Research Participants*

The research participants consisted of 34 eleventh-grade students and one physics teacher at SMAN 8 Makassar. Participants were selected using purposive sampling based on their direct involvement in the physics learning process and their ability to provide relevant information aligned with the research objectives.

## *Research Procedure*

The study was carried out through eight stages, namely (1) conducting a literature review on Project-Based Learning (PjBL), Python programming, and physics education; (2) developing the research instruments; (3) validating the instruments by two physics education lecturers and one physics teacher; (4) conducting classroom observations; (5) conducting interviews with the physics teacher and students; (6) administering the needs analysis questionnaire; (7) analyzing the collected data; and (8) developing recommendations for the implementation of Python-assisted PjBL.

## *Data Collection Techniques*

Observation was conducted to identify the current conditions of physics instruction, student learning activities, the use of instructional media, and the availability of technological facilities that support learning. Semi-structured interviews were conducted with the physics

teacher and several students to obtain information regarding challenges in physics learning, the need for instructional media, and readiness to use technology in the learning process. A questionnaire was used to identify students' needs regarding the implementation of Python-assisted PjBL. The questionnaire employed a five-point Likert scale consisting of Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1).

### *Data Analysis Techniques*

Observation and interview data were analyzed qualitatively through the stages of data reduction, data display, and conclusion drawing. Questionnaire data were analyzed using descriptive statistics, including mean scores and percentages, calculated using the following formula:

$$Percentage = Obtained\ Score / Maximum\ Score \times 100\%$$

The interpretation of the level of needs was based on the criteria presented in Table 1.

***Table 1.*** *Interpretation Criteria of the Level of Needs*

| Percentage | Category |
|---|---|
| 81–100% | Highly Needed |
| 61–80% | Needed |
| 41–60% | Moderately Needed |
| 21–40% | Less Needed |
| ≤20% | Not Needed |

The interpretation criteria in Table 1 are used to determine the level of need based on the percentage obtained from the needs analysis. A percentage of 81–100% indicates that the need is highly needed, while 61–80% indicates that the need is needed. A percentage ranging from 41–60% is categorized as moderately needed, whereas 21–40% indicates a less needed category. Finally, a percentage of ≤20% indicates that the identified aspect is not needed. These criteria provide a systematic basis for interpreting the results of the needs analysis and determining the priority of the needs identified.

## Result

### *Respondent Profile*

The study involved 34 eleventh-grade students and one physics teacher from SMAN 8 Makassar. All students had participated in regular physics classes and had experience using digital devices, such as smartphones and computers, in learning activities.

### *Results of the Observation of Physics Learning Conditions*

The observation results revealed that the physics learning process was still dominated by lecture-based instruction and problem-solving activities. The teacher acted as the primary source of information, while students tended to receive the material passively. The instructional media used mainly consisted of textbooks, student worksheets, and simple presentations. The utilization of digital technology as an interactive learning medium remained limited. Furthermore, student participation during the learning process was relatively low. Most students merely took notes and listened to the teacher's explanations, whereas discussion activities, concept exploration, and project-based learning activities had not been widely implemented. This condition indicates that physics instruction still requires innovations capable of increasing active student engagement. These findings are consistent with previous studies indicating that physics education continues to face challenges in promoting active

learning and developing 21st-century skills, thereby necessitating the integration of technology and innovative instructional models such as Project-Based Learning (PjBL).

### *Interview Results with Teachers and Students*

The interview results with the physics teacher revealed that one of the main challenges in physics instruction is the limited availability of media that can assist in visualizing abstract concepts such as motion, force, energy, and waves. The physics teacher stated: *"Students understand the material more easily when simulations or visual media are used; however, the available media are still limited, so instruction is more frequently conducted through direct explanation."* The teacher also noted that the integration of technology into instruction has not yet been optimal due to the lack of learning tools that align with the characteristics of physics content. Meanwhile, students reported that they were more interested in learning activities involving simulations, practical work, and project-based activities than in instruction focused solely on theoretical explanations. One student stated: *"I understand the material more easily when there are simulations or practical activities rather than only listening to the teacher's explanations."* These interview findings indicate a need for learning experiences that are more interactive, contextual, and technology-based.

### *Students' Needs Analysis*

#### Need for Technology-Based Learning

***Table 2.*** *Students' Needs for Technology-Based Physics Learning*

| Indicator | Percentage (%) | Category |
|---|---|---|
| Physics learning requires interactive media | 91.2 | Strongly Needed |
| Technology helps in understanding physics concepts | 92.4 | Strongly Needed |
| Technology-based learning is more engaging | 90.8 | Strongly Needed |
| Simulations or visualizations of physics concepts are needed | 93.1 | Strongly Needed |

The average level of students' need for technology-based learning reached 91.9%, which falls into the Strongly Needed category. This result indicates that students expect learning experiences that utilize technology to support the visualization and understanding of physics concepts.

#### Need for Project-Based Learning (PjBL)

***Table 3.*** *Students' Needs Analysis for the Implementation of Project-Based Learning (PjBL)*

| Indicator | Percentage (%) | Category |
|---|---|---|
| Enjoy project-based learning | 90.5 | Strongly Needed |
| Enjoy collaborative group work | 91.7 | Strongly Needed |
| Interested in producing learning products | 90.9 | Strongly Needed |
| Need more active learning experiences | 93.3 | Strongly Needed |

The average need for the implementation of PjBL reached 91.6%, indicating that students desire learning experiences that are more active, collaborative, and problem-solving oriented.

#### Need for the Use of Python

***Table 4.*** *Students' Needs for Python-Assisted Physics Learning*

| Indicator | Percentage (%) | Category |
|---|---|---|
| Interested in learning physics using Python | 90.4 | Strongly Needed |
| Python helps visualize physics concepts | 92.8 | Strongly Needed |
| Python can be used for physics simulations | 93.6 | Strongly Needed |
| Willing to participate in Python-assisted learning | 91.1 | Strongly Needed |

The average need for the use of Python reached 92.0%, which also falls into the Strongly Needed category. These findings indicate that students have positive perceptions regarding the use of Python as a medium for simulating and visualizing physics concepts.

### *Teachers' Needs and Infrastructure Readiness*

***Table 5.*** *Readiness for the Implementation of Python-Assisted PjBL*

| Aspect | Condition |
|---|---|
| Computer laboratory | Available |
| Internet access | Available |
| LCD projector | Available |
| School support | Good |
| Experience in using Python | Still limited |
| Teacher readiness | Moderately prepared |

The interview results showed that the teacher responded positively to the implementation of Python-assisted PjBL, as it was perceived to enhance student learning activities and support more contextualized learning experiences. Nevertheless, the teacher expressed the need for well-structured instructional materials and training related to the use of Python in physics education. From the perspective of facilities and infrastructure, the school has a computer laboratory, internet access, LCD projectors, and computer equipment that can support the implementation of technology-based learning. However, the utilization of these facilities in physics instruction has not yet been optimized. These findings indicate that the school has considerable potential to support the implementation of Python-assisted PjBL.

## Discussion

### *Physics Learning Conditions and the Urgency of Educational Innovation*

The observation results revealed that physics instruction at SMAN 8 Makassar is still predominantly characterized by lecture-based teaching, question-and-answer sessions, and problem-solving activities. This condition indicates that the learning process remains largely teacher-centered, limiting students' opportunities to actively participate in knowledge construction. In fact, physics learning requires active student engagement because many concepts are abstract and necessitate exploration, visualization, and investigation to develop deeper conceptual understanding.

These findings are consistent with the study of previous studied, which demonstrated that student-centered physics learning is more effective in fostering critical thinking skills than teacher-dominated instruction (Rasyid et al., 2024; Prayogi et al., 2024). Furthermore, the previous studied through their meta-analysis, concluded that learning approaches involving project activities and problem-solving contribute positively to the development of higher-order thinking skills and students' computational thinking (Zhang et al., 2024). Therefore, the learning conditions identified in this study indicate the need for instructional innovations that can enhance students' active engagement in the learning process.

The interview findings also revealed that students tend to be more interested in learning activities involving simulations, experiments, visualizations, and project-based tasks than in instruction focused solely on theoretical explanations. This finding suggests a gap between the characteristics of current instructional practices and students' learning needs. Consequently, a learning model that integrates project activities with digital technology is required to make physics learning more engaging, contextualized, and aligned with the characteristics of digital-generation learners (Maspul, 2024; Govender, 2025).

### *Need for Technology-Based Learning*

The needs analysis results indicate that students have a very high demand for technology-based learning. This finding suggests that students perceive technology as a means of helping them understand physics concepts that are often considered difficult and abstract. In physics education, technology plays an important role because it can provide visual representations of phenomena that are difficult to observe directly. Through simulations, animations, and interactive visualizations, students can connect mathematical concepts with real physical phenomena, making learning more meaningful. This finding is consistent with the study by the previous studied, which showed that interactive web-based learning media can support the development of critical thinking skills and help students understand physics concepts more effectively (Doyan et al., 2025).

Moreover, the advancement of digital technology has shifted the educational paradigm from merely delivering information to promoting exploration and knowledge construction. The previous studied explained that technology integration in education not only supports the achievement of learning objectives but also contributes to the development of digital literacy, which is one of the essential competencies of the 21st century (Govender, 2025). Therefore, the high level of need for technology-based learning indicates that technology integration in physics education is highly relevant to contemporary educational developments. However, the findings of this study should not be interpreted as evidence that technology automatically improves learning outcomes. The results merely indicate students' needs and positive perceptions regarding the use of technology in physics learning. The effectiveness of technology integration must still be verified through experimental studies during subsequent implementation stages.

### *Need for the Implementation of Project-Based Learning (PjBL)*

The findings indicate that students have a very high need for the implementation of Project-Based Learning (PjBL). This high level of need reflects students' desire for learning experiences that are more active, collaborative, and oriented toward problem-solving. Project-Based Learning is an instructional model that provides students with opportunities to construct knowledge through investigative activities and project development. In this model, students do not merely receive information from the teacher but actively engage in identifying problems, planning projects, carrying out activities, and presenting the results. These characteristics align closely with the students' needs identified in this study.

This finding is supported by previous studied, who reported that PjBL contributes positively to the development of students' computational thinking (Zhang et al., 2024). The another studieds also demonstrated that integrating PjBL into science education can enhance critical thinking and problem-solving skills (Verawati et al., 2025). Furthermore, the previous studied found that PjBL is among the most widely used approaches in the development of technology-based physics learning media because it effectively promotes active student participation (Doyan et al., 2025). Therefore, the high demand for PjBL indicates that this model has substantial potential to be implemented as an alternative student-centered approach to physics learning. Nevertheless, this study did not evaluate the effectiveness of PjBL implementation; thus, the conclusions are limited to identifying needs and implementation potential.

### *Need for the Use of Python in Physics Learning*

The findings indicate that the use of Python in physics learning received a very high level of need. This result suggests that students have positive perceptions regarding the integration of programming technology into the learning process. Python is one of the most widely used programming languages in education, science, and engineering because of its relatively simple syntax and extensive libraries that support data visualization, simulations, and numerical analysis. In physics education, Python can be utilized to create motion simulations, analyze experimental data, and visualize relationships among physical variables through graphs and animations.

These findings are consistent with the study by previous studied, which demonstrated that Python can help students analyze experimental physics data more systematically (Kurmangaliyeva et al., 2025). Similarly, that integrating Python into STEM-based learning supports the development of problem-solving skills and computational thinking (Subramaniam et al., 2025). Furthermore, the previous studied identified computational thinking as an increasingly important competency in modern physics education (Riwayani et al., 2025). Nevertheless, these findings should be interpreted with caution. A high level of need for Python does not necessarily imply that all students already understand or can use the programming language. Most students likely responded based on their perceptions of the general benefits of technology. Therefore, the implementation of Python in physics learning should be accompanied by learning activities tailored to students' skill levels and supported by adequate instructional guidance.

### *Teacher Readiness and Supporting Infrastructure*

The successful implementation of educational innovation depends not only on students' needs but also on teacher readiness and the availability of supporting facilities. The findings indicate that the school possesses adequate facilities, including a computer laboratory, internet access, and projection equipment that can support technology-based learning. In addition, the teacher expressed a positive attitude toward the use of technology and project-based instructional models in physics education. However, interview results revealed that the teacher's experience with Python remains relatively limited. This finding suggests that the primary challenge lies not in infrastructure availability but rather in human resource readiness.

Teacher competence is the key factor determining the successful integration of computational thinking and technology in STEM education (Adhantoro et al., 2025). Similar findings were reported by previous studied, who emphasized that improving teachers' digital literacy is a prerequisite for implementing technology-based learning (Govender, 2025). Therefore, before large-scale implementation can occur, training and mentoring programs are needed to help teachers understand how to use Python in physics education and how to integrate it effectively within the PjBL framework.

### *Research Contributions and Implications*

This study contributes empirical information regarding the need for implementing Python-assisted Project-Based Learning in secondary school physics education. Unlike most previous studies that focused on evaluating the effectiveness of instructional models, this research emphasizes needs analysis as a preliminary stage prior to development and implementation. The findings indicate that students require learning experiences that are more active, technology-based, and provide opportunities to explore concepts through project activities. Furthermore, the study demonstrates that the school has considerable potential to support the

implementation of Python-assisted PjBL, although improvements in teacher competence are still necessary. These findings can serve as a foundation for developing PjBL–Python-based physics learning materials, designing teacher professional development programs, and conducting future studies that examine the effectiveness of the model in improving learning outcomes, critical thinking skills, creativity, and students' computational thinking.

### *Research Limitations*

This study has several limitations. First, the research was conducted in only one school; therefore, the findings cannot be generalized to all secondary schools. Second, the study focused solely on needs analysis and did not evaluate the effectiveness of Python-assisted Project-Based Learning in physics education. Third, most students had no prior experience using Python; therefore, their responses primarily reflected perceptions of technology use rather than actual experience with the programming language. Accordingly, future research should involve a larger number of participants and proceed to the development and implementation stages to obtain a more comprehensive understanding of the effectiveness of Python-assisted Project-Based Learning in physics education.

## Conclusion

This study concludes that students at SMAN 8 Makassar have a strong need for technology-based physics learning that incorporates Project-Based Learning (PjBL) and Python programming. The findings also reveal that the school has adequate technological facilities and positive teacher support, providing a favorable environment for implementing Python-assisted PjBL. These conditions indicate that Python-assisted PjBL has considerable potential as an innovative approach to improve the quality of physics learning by connecting theoretical concepts with practical and computational activities. However, this study is limited to a needs analysis conducted at a single school and does not yet examine the effectiveness of its implementation. Therefore, future research should focus on developing, validating, and implementing Python-assisted PjBL learning materials and assessing their effectiveness in improving students' conceptual understanding, critical thinking, problem-solving, and computational thinking skills. Further studies involving larger and more diverse samples across different schools and educational contexts are also recommended to strengthen the generalizability of the findings and provide broader evidence for the integration of Python-assisted PjBL in physics education.

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