*International Journal of Learning, Teaching and Educational Research*
*Vol. 24, No. 12, pp. 97-117, December 2025*
*https://doi.org/10.26803/ijlter.24.12.5*
Received *Sept 16, 2025; Revised Oct 26, 2025; Accepted Oct 30, 2025*

# Identifying Students' Demand to Develop Project-Based Learning Model Integrated with Problem-Solving to Support Independent Research in Higher Education

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**Abstract.** Problem-solving skills are vital in the 21st century, as technology-driven contexts demand open-minded thinking, innovation, and solution-oriented abilities. This study aimed to identify students' demands in developing a project-based learning (PjBL) model integrated with problem-solving to support independent research competence in higher education. Conducted as a preliminary phase of a multi-year project, the research employed a descriptive quantitative design supported by qualitative interviews. The sample consisted of 98 undergraduate students selected through purposive sampling at STKIP Andi Matappa, with follow-up interviews involving three representatives. Data was analyzed using descriptive statistical techniques and thematic analysis. The results showed that although students were familiar with PjBL, they faced challenges in accessing resources, conducting literature reviews, and applying research methodologies. Their understanding of research processes was moderate, while knowledge of Yimer and Ellerton's problem-solving stages remained low. Students emphasized the need for structured guidance, training workshops, and greater access to academic resources. These findings highlight the urgency of developing a contextually adapted PjBL model integrating orientation, planning, investigation, analysis-reflection, and communication stages to enhance students' independent research abilities.

**Keywords:** Students' Demand; Project-Based Learning; Problem-Solving; Yimer and Ellerton; Research

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## 1. Introduction

The 21st century is marked by increasingly advanced, intelligent, and sophisticated information technology (Popkova et al., 2019; Zhang & Ma, 2023). The utilization of technology has expanded into higher education, resulting in a paradigm shift in learning. Whereas educators were once the sole source of scientific knowledge, today all information required by students can be accessed through online media (Bratslavsky et al., 2019). This also extends to the obligation of students to produce research. A preliminary study was carried out in March 2025 at STKIP Andi Matappa involving 30 sixth-semester students enrolled in the Educational Research Methodology course. Data were collected through a questionnaire.

The findings revealed that the majority of students encountered difficulties in formulating research problems, selecting appropriate research methods, and conducting data analysis systematically. Only 27% were able to formulate researchable problems, 65% failed to justify their methodological choices, and 70% reported challenges in analyzing data. Overall, the results indicate that students' ability to conduct independent research remains low, as reflected in their difficulties in formulating research problems, selecting appropriate methods, and carrying out the research process systematically. This limitation is influenced by the lack of habituation to scientific thinking and the dominance of teacher-centered learning (Ghafar, 2023). Consequently, research is often perceived merely as an academic requirement rather than as an integral part of critical thinking and the problem-solving processes that are essential in the 21st century (Walker, 2025).

As the education sector increasingly depends on technology, there is a growing demand for skills that involve generating new ideas and consistently providing solutions to various challenges. Such skills include the ability to detect gaps, propose multiple solutions to problems, generate new ideas, reorganize existing ideas, and suggest new relationships among them (Jankowska et al., 2019). Therefore, problem-solving competence is highly essential in the 21st century (Lavado-Anguera et al., 2024). The ability to provide solutions to diverse problems-where one's thinking is systematically directed toward resolving the challenges encountered - also constitutes a fundamental component of problem-solving (Wahyuti et al., 2023).

There is substantial evidence indicating that individuals who apply problem-solving strategies efficiently tend to achieve higher academic performance and learning outcomes (Jiang et al., 2021). Findings from Tukan et al. (2024) support the claim that effective problem-solving strategies enhance academic achievement in mathematics, particularly in mathematical problem-solving skills. Moreover, Sukendra and Sumandya (2019) found that factorial/experimental studies demonstrate a significant effect of employing problem-solving strategies especially for open-ended questions on improving learning outcomes, moderated by students' metacognitive skills. Additionally, problem-solving as a learning approach enables students to articulate their thinking processes, transform

information into various representational forms, and adapt effectively to online learning environments (Ashari et al., 2021).

Polya proposed that problem-solving involves four stages: understanding the problem, devising a plan, executing the plan, and monitoring and reflecting on the solution (Masito et al., 2024). Over the past decades, researchers have expanded Polya's four-stage framework and developed new models, which are variations aimed at understanding the cognitive and metacognitive aspects underlying the problem-solving process (Yimer & Ellerton, 2010). Lester's stages of problem-solving remain rooted in Polya's framework; however, these stages should be understood as a dynamic process influenced by cognitive, metacognitive, and affective factors, rather than merely as a sequence of procedural steps.

Yimer and Ellerton elaborated Polya's model into five phases; Engagement, Transformation-Formulation, Implementation, Evaluation, and Internalization, highlighting students' cognitive and metacognitive behaviors at each stage (Jiang et al., 2021; Yimer & Ellerton, 2010). Yimer and Ellerton's problem-solving model offers a more comprehensive, adaptive, and reflective approach compared to Polya's and Lester's. Each phase engages both cognitive and metacognitive processes, supporting learning and internal reflection, particularly for pre-service teachers and students (Yimer & Ellerton, 2006, 2010).

Several studies have also noted that traditional teacher-centered pedagogical methods, which focus on unidirectional knowledge delivery, are often inadequate for addressing current educational challenges (Hu, 2024; Indriani et al., 2021). As an alternative, student-centered pedagogy, such as project-based learning (PjBL), has emerged as a promising approach (Lavado-Anguera et al., 2024). This learner-centered teaching method directly aims to foster 21st-century skills, particularly higher-order thinking skills. Higher-order thinking emerges through problem-solving, which involves challenging tasks that emphasize real-world situations and open-ended environments. PjBL motivates students to continuously explore during the problem-solving process, thereby promoting the development of higher-order thinking skills (Zhang & Ma, 2023).

Numerous studies have demonstrated the effectiveness of the PjBL model in education (Fitrah et al., 2025). Research by Masdarini et al. (2024) and Rahayu et al. (2025) indicates that the development of PjBL in entrepreneurship courses effectively enhances students' creativity. STEM-integrated PjBL has also been shown to improve junior high school students' mathematical critical thinking skills (Priatna et al., 2020). Furthermore, Zhang and Ma (2023) found that PjBL significantly increases learning outcomes compared to traditional instruction. Quantitative analyses have reported improvements in students' 21st-century competencies (innovation, collaboration, and critical thinking) through PjBL (Zhang et al., 2024).

However, most studies focus on theoretical aspects or general model implementation without first assessing students' actual needs (Nieminen et al.,

2023). Learning models that ignore students' experiences and prerequisites often remain theoretically effective but may be less relevant in practice. Therefore, identifying students' needs is crucial to ensure that PjBL models are relevant, applicable, and capable of fostering critical thinking and problem-solving (Umbu Runga Riti et al., 2021). Constructivist theory emphasizes that meaningful learning occurs when knowledge is built upon learners' prior experiences and schemas, highlighting the importance of aligning PjBL with student's needs (Mcleod, 2025).

Moreover, research on the integration of project-based learning with problem-solving in higher education remains limited. Most studies treat the two approaches separately (Azizah et al., 2022), whereas 21st-century challenges require students not only to engage in projects but also to systematically internalize problem-solving strategies. Based on a review of previous studies, several researchers have examined the implementation of PjBL and problem-solving separately (Umbu Runga Riti et al., 2021). However, prior studies tend to (1) focus on theoretical aspects without exploring students' actual needs (Basir et al., 2022); (2) use samples from different educational levels or contexts; or (3) measure different outcomes (e.g., critical thinking skills) (Ibnu Sholeh et al., 2024). This study is unique because it conducts a needs assessment prior to designing a PjBL model integrated with problem-solving.

PjBL is employed as the main instructional framework that enables students to directly experience the research process—from problem formulation to reporting the findings—whereas problem-solving serves as the core thinking process or cognitive approach integrated into each stage of PjBL (Novalis et al., 2025). This integration ensures that students do not merely "carry out a project" but genuinely engage in solving research problems in a reflective and systematic manner (Sánchez-García & Reyes-de-Cózar, 2025). Therefore, PjBL emphasizes "what students do" (project activities and products), whereas problem-solving emphasizes "how students think and resolve problems" (cognitive and reflective processes).

Therefore, this study aims to address this gap by identifying students' demands in developing a PjBL model integrated with problem-solving. The findings are expected to provide a foundation for designing a more comprehensive, adaptive, and contextually relevant learning model in higher education. Specifically, this study sought to: (1) identify students' demands in developing a PjBL model integrated with problem-solving; (2) explore the aspects most required by students to support learning and independent research; and (3) formulate an initial design of the learning model based on the identified needs.

## 2. Literature Review

This section should explain the definitions of the project-based learning (PjBL) model, problem-solving limited to the Yimer and Ellerton's framework, and independent research, in accordance with the variables of this study.

**2.1 Project-Based Learning (PjBL)**

Project-based learning (PjBL) is a student-centered approach that engages learners as active participants in authentic projects linked to real-world contexts. It fosters 21st-century skills, including critical thinking, collaboration, communication, creativity, and problem-solving, while integrating knowledge and application to produce tangible outcomes (Wiyati et al., 2024). PjBL emphasizes inquiry through investigation, design, decision-making, and reflection (Bell, 2010). Its stages include essential problems, project design, scheduling, constructive investigations, autonomy, outcome assessment, and realism (Fisher et al., 2020).

PjBL, as a student-centered approach, plays a crucial role in enhancing 21st-century skills such as computational thinking and problem-solving in mathematics education (Fitrah et al., 2025). At the elementary level, PjBL requires students to recall and comprehend concepts as well as key information relevant to their projects. As they progress, students apply this knowledge in real-world contexts, addressing practical problems that demand critical thinking. The iterative nature of PjBL encourages students to analyze and evaluate their findings and processes, thereby fostering deeper understanding and refinement of their work (Lavado-Anguera et al., 2024).

PjBL is considered an innovative instructional model designed to encourage students to engage more extensively in independent learning processes, which can be carried out anywhere and are not limited to face-to-face settings. PjBL involves students in problem-solving activities and provides opportunities for them to work independently, construct their own learning, and ultimately produce meaningful and realistic products (Fisher et al., 2020). A set of skills is demonstrated by all learners in PjBL activities, including organization, planning, problem-solving, and analysis/reflection (DuBois & Keller, 2016). In the context of STEM, PjBL is implemented through five stages of learning: reflection, research, discovery, application, and communication (Eja et al., 2020).

**2.2 Problem-Solving following Yimer and Ellerton**

The National Council of Teachers of Mathematics recommends that problem-solving be the primary focus of mathematics instruction in schools (National Council of Teachers of Mathematics, 2000). Within the five strands of mathematical proficiency, problem-solving is linked to strategic competence (formulating and solving problems), adaptive reasoning (logical thinking and justification), and productive disposition (seeing mathematics as meaningful and useful, which encourages perseverance) (Kilpatrick & Swafford, 2002). Problem solving in mathematics is understood as a cognitive and metacognitive process that encompasses how students orient themselves to a problem, organize information, execute strategies, and verify results (Garofalo & Lester, 1985).

Problem-solving is an integrated process involving the interaction of knowledge (resources), strategies (heuristics), self-regulation (metacognition), and individual beliefs (belief system), with the aim of identifying, testing, and interpreting solutions to non-routine problems (Schoenfeld, 2016). Problem-solving refers to the process of addressing non-routine mathematical problems that encompasses both cognitive and metacognitive aspects, requiring the interaction between

cognition (knowledge, strategies, computations) and metacognition (monitoring, evaluation, self-reflection) (Yimer & Ellerton, 2006).

Based on Yimer and Ellerton's conceptualization, problem-solving serves as a structural framework for the problem-solving process in teaching practice. This model provides a reference point for developing problem exposition and instructional strategies in the classroom (Brungs et al., 2025). It consists of five main phases: engagement, transformation–formulation, implementation, evaluation, and internalization, each embedded with both cognitive and metacognitive actions. The process is non-linear (with multiple pathways), allowing movement across phases as needed. The final phase, internalization, emphasizes integrating strategies into learners' mental preparedness for long-term problem-solving (Yimer & Ellerton, 2010).

### 2.3 Research

Research in higher education is understood in a specific sense, not merely as "faculty research" or "undergraduate theses," but as a systematic process for generating new knowledge, an activity that develops students' competencies, a pillar of research-oriented teaching, and an interdisciplinary endeavor (Böttcher & Thiel, 2018). Research is not limited to formal academic projects; rather, it is a transformative learning experience that shapes students' self-efficacy, fosters positive expectations about the value of research, and serves as an inclusive avenue for all students, including first-generation learners (Jones et al., 2023).

Research is not only a means of producing new knowledge but also a pedagogical tool for developing critical thinking, problem-solving, collaboration, and communication skills. The six stages of research-based pedagogy can significantly strengthen students' research competence, particularly in problem-solving, self-directed learning, communication, and collaboration. These six stages include inspiring, ideating, action, refining, reporting, and rewarding (Hegde & Karunasagar, 2021). Research encompasses diverse forms of scientific inquiry that train students to think critically, synthesize information, and generate new knowledge, extending beyond laboratory experiments (Manitzas Hill et al., 2022).

## 3. Methodology

This study is part of a project developing a project-based learning (PjBL) model integrated with problem-solving to support students' independent research. Funded as a fundamental regular research (PFR) project by the Directorate General of Research and Development, Ministry of Education, Culture, Research, and Technology, the model development is scheduled for 2025–2028.

### 3.1 Research Design

The research adopted the Plomp's educational design research model, consisting of three phases: (1) the preliminary research phase, which included needs analysis and students' prior knowledge, literature review, and the development of a conceptual framework for the study; (2) the development/prototyping phase - designing and validating the prototype model; and (3) the assessment phase -

evaluating model effectiveness in actual classroom settings (Plomp & Nieveen, 2013).

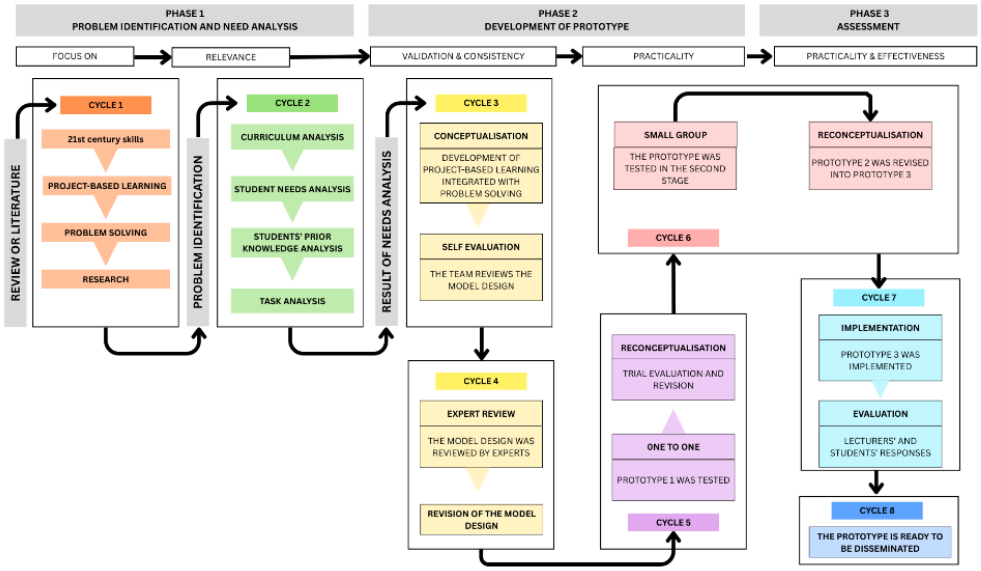


**Figure 1: Flow of Activities in Developing a Project-Based Learning Model Integrated with Problem-Solving**

In 2025, the study only reached the first phase of development (preliminary research), which is expected to provide an understanding of the concepts, theories, principles, or laws underlying the development of the PjBL model integrated with problem-solving. Since the objectives of this research were to identify students' demands in developing the model and to formulate the initial design of the PjBL model integrated with problem-solving, the research employed a descriptive quantitative approach for data collection and drawing conclusions in this study.

### 3.2 Research Instrument

The instruments used in this study consisted of: (1) a student needs questionnaire comprising 26 items: to explore expectations, challenges, and required support for effective project-based and independent research learning; (2) a prior knowledge questionnaire comprising 23 items: to assess students' existing competencies after completing the Research Methodology course; and (3) an interview guide containing 17 structured questions: to gain deeper insights into students' needs, experiences, and perspectives related to students' needs and prior knowledge.

The questionnaires were administered online and included both closed- and open-ended questions. The interview questions were grouped into three thematic areas (learning resource accessibility, methodological competence, and expected support for independent research). Student needs are defined as expectations, challenges, and aspects required by students to ensure that project-based learning and independent research can be more effective, focusing on content, learning models, instructional materials, skills to be developed, and user needs (Bashir et al., 2025). Prior knowledge refers to the fundamental competencies already

acquired by students after completing the Research Methodology course and through previous academic experiences (Binder et al., 2019; Böttcher & Thiel, 2018; Puji et al., 2020). These needs and prior knowledge reflect what students require for the optimal development of a PjBL model integrated with problem-solving.

The indicators of students' needs used in this study included: (1) prior experience with PjBL; (2) access to and availability of learning resources; (3) learning barriers; and (4) expected support. The indicators of students' prior knowledge included: (1) understanding of problem formulation; (2) understanding of research methodology; (3) ability in literature review; (4) data processing and analysis skills; (5) scientific communication; and (6) knowledge of problem-solving.

The questionnaires were developed through adaptation from previously validated instruments by Binder et al. (2019) and Bashir et al. (2025) and refined through expert judgment by two research and problem-solving experts and one PjBL specialist to ensure content validity and contextual relevance. The reliability test indicates the extent to which measurement results remain consistent when the same phenomenon is measured two or more times. To assess reliability, Cronbach's alpha coefficient followed Furchan (2007). The interview guide was adapted from Creswell and Creswell (2018) and refined after a pilot interview with two students to ensure clarity and appropriateness of wording. The following is the classification of reliability coefficients used in this study.

**Table 1: Classification of Reliability Coefficients**

| Score of $r_{11}$ | Reliability |
|---|---|
| $0.80 < r_{11} \leq 1.00$ | Very high |
| $0.60 < r_{11} \leq 0.80$ | High |
| $0.40 < r_{11} \leq 0.60$ | Moderate |
| $0.20 < r_{11} \leq 0.40$ | Low |
| $r_{11} \leq 0.20$ | Very Low |

The questionnaires were pilot-tested with 30 students who were not included in the main study to assess the clarity and reliability of the items. Content validity was evaluated by two experts using a four-point relevance scale. Based on their feedback, minor revisions were made to improve wording and contextual accuracy. The reliability of the instruments was examined using Cronbach's alpha, which yielded coefficients of 0.72 for the students' needs questionnaire and 0.84 for the prior knowledge questionnaire, indicating a high level of internal consistency.

### 3.3 Data Collection

The data collection techniques in this study involved administering questionnaires and conducting interviews with students. The population of this study comprised all sixth-semester students of STKIP Andi Matappa in the 2024/2025 academic year, totaling 155 students. The selection of sixth-semester students was based on the consideration that they had completed the Research

Methodology course and were preparing to undertake their actual research projects. From this population, 98 students were selected as the sample to complete the needs and prior knowledge questionnaires. Sampling was conducted using purposive sampling with inclusion criteria (Creswell & Creswell, 2018). The inclusion criteria for this study were as follows: participants were active students of STKIP Andi Matappa in the 2024/2025 academic year who were enrolled in the sixth semester at the time of data collection. They had completed and passed the Research Methodology course, were willing to participate voluntarily, and had provided informed consent prior to data collection.

Students were required to complete the needs and prior knowledge questionnaires in full and be able to communicate effectively in Bahasa Indonesia to understand and respond to the research instruments. From the 98 students who completed the questionnaire, three students were selected for interviews. The selection of these three students was based on purposive sampling, considering the questionnaire results (high, medium, and low prior knowledge scores), as well as their study program and research experience, to obtain diverse perspectives (Patton, 2002).

### 3.4 Ethical Consideration

Participation in this study was voluntary. Participants were informed about the purpose and procedures of the research prior to providing their consent to participate. All data were kept confidential and used solely for research purposes, in accordance with the ethical standards of the Ministry of Education, Science, and Technology, and the approval of the Ethics Review Board of STKIP Andi Matappa.

### 3.5 Data Analysis

The data analysis techniques employed in this study consisted of quantitative descriptive analysis for questionnaire data (using descriptive statistics such as percentages, frequencies, means, or categorical scores), and qualitative analysis for interview data (data reduction, thematic categorization, and conclusion drawing) (Najmah et al., 2023). The student needs questionnaire contained 22 statements with Yes or No responses (Sugiyono, 2013) and four open-ended questions. The categorization of students' initial needs is presented in Table 2 below.

**Table 2: Categorization of Students' Initial Needs**

| Indicator | Categories | | |
|---|---|---|---|
| | **≥ 75% of the maximum score** | **50% – 74% of the maximum score** | **< 50% of the maximum score** |
| Prior experience with PjBL | Often | Rarely | Never |
| Access to and availability of learning resources | Helpful | Less helpful | Not helpful |
| Learning barriers | High | Medium | Low |
| Expected support | Important | Less Important | Not Important |

Source adapted from Wahyudi et al. (2023)

The students' prior knowledge questionnaire consisted of 23 closed-ended items using a four-point Likert scale (strongly agree, agree, disagree, and strongly disagree) and two open-ended items, with a total of 98 respondents (Sugiyono, 2013). The categorization of students' prior knowledge after converting the questionnaire scores into percentages is presented below.

**Table 3: Categorization of Students' Prior Knowledge**

| Score | Category |
|---|---|
| ≥ 75% | High |
| 50% – 74% | Medium |
| < 50% | Low |

Source adapted from Wahyudi et al. (2023)

The data obtained from the questionnaires were analyzed using descriptive statistics and visualized through graphical representations in MS Excel. The interview data were analyzed qualitatively.

## 4. Results

This section presents the results and findings of the study to address the three research questions, with the analysis discussed as follows.

### 4.1 Results of Students' Initial Needs

Based on the data analysis of students' initial needs, the results are illustrated in Figure 2 below.

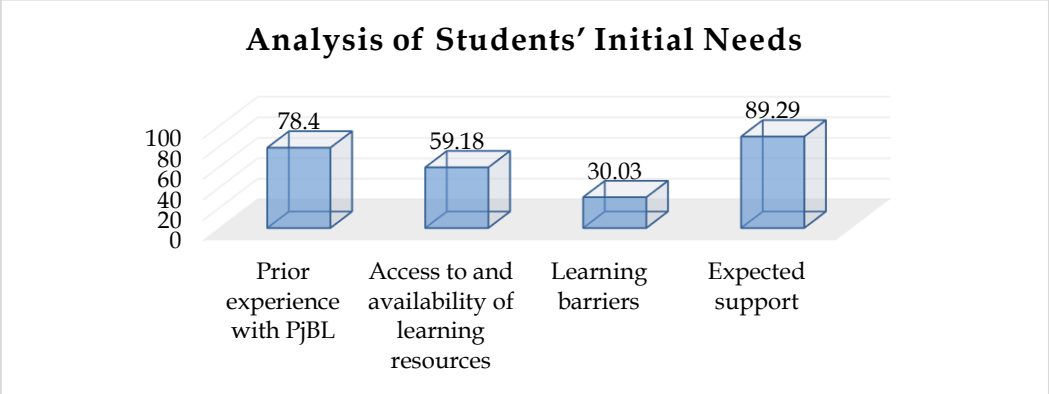


**Figure 2: Percentage Analysis of Students' Needs for Each Indicator**

Referring to Figure 2 above, it was evident that the PjBL model was not unfamiliar to students, indicating that lecturers at STKIP Andi Matappa have frequently implemented this instructional approach. However, students' access to and availability of learning resources related to PjBL and their assignments remained insufficient in providing adequate support. The identified learning obstacles encountered by students and in lecturers' teaching practices were relatively low, which suggests that students demonstrate a strong enthusiasm for learning despite limited access to and availability of learning resources. Therefore, the questionnaire results indicated that students are in great need of supplementary learning resources to ensure that both aspects can operate in a complementary

manner. The findings for each indicator are further elaborated into sub-indicators, as presented in Table 4 below.

**Table 4: Results of Students' Initial Needs Analysis by Sub-Indicator**

| Indicator | Sub-Indicator | Percentage (%) | Category |
|---|---|---|---|
| Prior experience with PjBL | Experience in completing project assignments | 77.21 | Often |
| | Understanding of lecturers' instructions | 78.57 | Often |
| | Independence in comprehending project steps | 81.63 | Often |
| Access to and availability of learning resources | Utilization of formal learning resources | 50.00 | Less helpful |
| | Limitations in the use of resources | 63.27 | Less helpful |
| | Independent learning habits | 68.88 | Less helpful |
| Learning barriers | Motivation and study habits | 40.82 | Low |
| | Perceptions of lecturers' teaching | 7.14 | Low |
| | Academic writing skills | 30.36 | Low |
| Expected support | Need for additional learning resources | 89.29 | Important |

The results of the needs analysis of students, as presented in Table 4, indicated that students' experiences with the PjBL model—specifically the sub-indicators of experience in completing project-based tasks (77.21%), comprehension of lecturers' instructions (78.57%), and independence in understanding project steps assigned by lecturers (81.63)—were all categorized as frequent. This finding indicated that students at STKIP Andi Matappa are already accustomed to the PjBL model, which is widely applied across various courses, and that they are reasonably capable of understanding instructions and completing projects independently.

In terms of access to and utilization of learning resources, the findings revealed that students' conditions remain less supportive. The use of formal learning resources (50%), limitations in resource utilization (63.27%), and habits of independent study (68.88%) were all categorized as insufficient. This indicates that students experience limitations in accessing books, journals, or online resources and still tend to rely on limited sources such as the library or information provided by lecturers. Meanwhile, the learning barriers assessed through motivation and study habits (40.82%), perceptions of lecturers' teaching (7.14%), and academic writing skills (30.36%) were all categorized as low.

The most prominent indicator was the support expected by students, with a percentage of 89.29%, which was categorized as important. Students explicitly expressed the need for supplementary learning resources to support the implementation of PjBL and their independent research. The responses to the open-ended questions provided by students concerning the indicator of expected support are presented below.

**Table 5: Responses to Open-Ended Questions on the Expected Support Indicator**

| The Students' Responses |
|---|
| 1. I need clear guidance and detailed explanations from the lecturer to help me understand how to identify a suitable research problem.<br>2. Constructive feedback and practical examples from the lecturer would make it easier for me to formulate a research topic.<br>3. It would be very helpful if the lecturer could provide additional references and recommended readings to broaden my understanding of the topic. |
| 1. I think having structured and regular guidance sessions would help me stay on track during the literature review process.<br>2. I would really appreciate technical training on how to search for relevant journals, conduct critical reading, and synthesize research findings.<br>3. The campus should provide workshops or intensive training sessions specifically focused on writing literature reviews. |
| 1. I need a clearer understanding of research methodology concepts and how to apply them correctly.<br>2. Having examples of research designs from previous studies would help me understand how to structure my own methodology.<br>3. Training on research ethics and how to interact properly with respondents would be very beneficial.<br>4. I need to better understand the alignment between research objectives and methods, so that my methodology stays focused. |
| 1. I hope the institution can provide broader and easier access to national and international journals.<br>2. It would be great to have intensive mentoring from the beginning to the end of the research process.<br>3. I think having a research center or dedicated research facilities on campus would be very helpful.<br>4. It would be beneficial if the campus could provide adequate research equipment and facilities, such as data analysis software and quiet workspaces. |

The results of the open-ended question analysis presented in Table 5 provided an overview of the types of support expected by students. First, students required intensive guidance and direction from lecturers, including concrete examples and structured feedback in identifying research problems and formulating research topics. Second, with regard to conducting literature reviews, students expected technical training on how to search for journals, engage in critical reading, perform synthesis, and write literature reviews, even suggesting the organization of specialized workshops.

Third, in terms of research methodology design, students emphasized the importance of understanding applicable methodological concepts, supported by real-life examples, as well as knowledge of research ethics and skills in engaging with respondents. Fourth, at the institutional level, students expected support in the form of broader access to national and international journals, the establishment of a campus-based research center, and research mentoring from the initial stages through to the completion of their studies.

### 4.2 Results of Students' Prior Knowledge

The results of data analysis regarding students' prior knowledge are as presented in Figure 3 below.

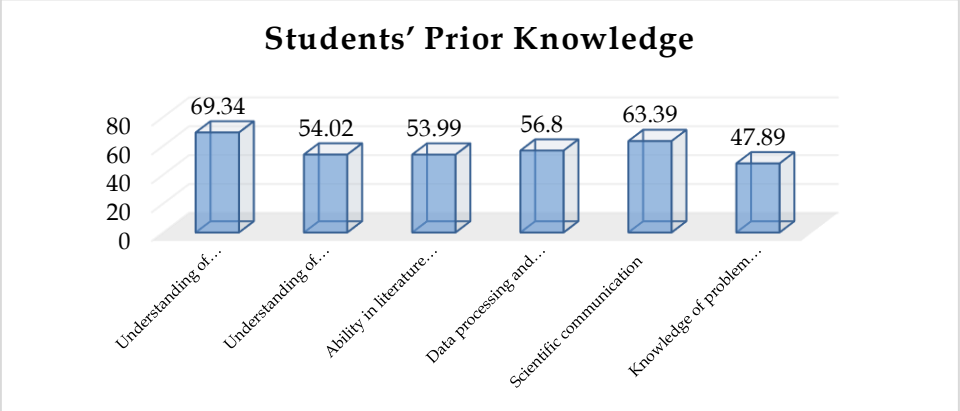


**Figure 3: Percentage Analysis of Students' Knowledge for Each Indicator**

Based on Figure 3 above, it is evident that some students already understand the fundamentals of problem formulation. The analysis of research methodology comprehension fell within the moderate category, indicating that students are familiar with the stages of methodology but are not yet fully capable of selecting and applying appropriate research methods.

The results also showed that students have a foundational ability to compile a literature review, though their access to resources and critical reading skills remain limited. This indicator represented one of the major challenges in independent research. Students' skills in data processing and analysis were categorized as moderate, meaning that their ability to manage research data and apply analytical techniques is still very limited. Students' prior knowledge in writing and presenting research findings scientifically demonstrated reasonable potential but still requires specialized training.

Students' understanding of problem-solving was categorized as low. Most students have only encountered the term problem-solving (Polya or Yimer & Ellerton) but do not yet comprehend the steps involved in its application. This condition indicated that problem-solving skills have not yet been internalized within students' research competencies, highlighting the need for structured learning and mentoring. The following were the interview findings from three students to assess their research needs.

**Table 6: Interview Findings from Three Students with High, Medium, and Low Initial Ability**

| Codes (Initial Meaning Units) | Categories | Themes |
|---|---|---|
| *We mostly rely on lecturer's materials.* | Limited access to academic resources | Learning Resource Accessibility |
| *We cannot access many journals or articles online.* | Lack of access to scholarly databases | Learning Resource Accessibility |
| *Sometimes I just follow examples from seniors.* | Inability to select appropriate research methods | Methodological Competence and Problem-Solving Skills |
| *I can write a proposal, but I'm not sure which method fits my topic.* | Difficulty applying research methodology | Methodological Competence and Problem-Solving Skills |
| *We need more mentoring from lecturers.* | Expectation of lecturer guidance | Expected Support for Independent Research |
| *We hope there will be workshops about literature review.* | Need for research training and technical support | Expected Support for Independent Research |
| *It's hard to find clear examples from previous studies.* | Lack of practical learning resources | Learning Resource Accessibility |
| *I get confused analyzing data after collecting it.* | Low analytical confidence | Methodological Competence and Problem-Solving Skills |
| *We want access to international journals and research centers.* | Expectation for institutional facilities | Expected Support for Independent Research |

Based on Table 6 above, three dominant themes emerged: (1) learning resource accessibility, (2) methodological competence, and (3) expected support for independent research.

Quantitative data indicated that 68.88% of students categorized their independent learning habits as "less helpful," while 63.27% reported limited use of available resources. These findings revealed that students experienced significant constraints in accessing books, journals, and online learning materials.

This pattern was supported by qualitative data, as students repeatedly expressed difficulties in obtaining relevant academic references. One student stated, "We mostly rely on the lecturer's materials because we cannot access many journals or articles online." The convergence of both data sets highlights that insufficient access to learning resources remains a key obstacle to implementing PjBL effectively.

The quantitative findings showed that students' prior knowledge of research methodology and problem-solving skills was in the moderate category (50–74%). Most students understood the general steps of research but lacked the ability to select and apply appropriate methods or analyze data effectively. The qualitative interviews reinforced this result. Students revealed that they often faced confusion in choosing research designs and applying analytical techniques. For instance, one participant said, "I can write a proposal, but I am not confident in deciding which method fits my topic." This theme illustrates that while students

have theoretical knowledge, they need more structured training to internalize the practical application of problem solving within research contexts.

The quantitative results demonstrated that 89.29% of students categorized the need for additional learning support as "important." This was consistent with the qualitative findings, where most students emphasized the importance of guidance from lecturers, access to journals, and practical workshops. A representative quote stated, "We need more mentoring and workshops about how to search for journals and write literature reviews." This indicates that students highly value structured mentoring and accessible research resources as critical supports for developing independent research competence.

## 5. Discussion

The integration of quantitative and qualitative data revealed a comprehensive picture of students' needs and prior knowledge in developing a project-based learning (PjBL) model integrated with problem solving. The findings indicated that students faced considerable challenges in accessing adequate learning resources, including scholarly journals and digital databases. This aligns with the results of Bashir et al. (2025), who found that limited access to academic resources hinders students' engagement in inquiry-based and project-oriented learning. Although students were familiar with PjBL activities, their independent learning habits were categorized as "less helpful" in the quantitative results (68.88%). The qualitative data supported this, showing repeated mentions of students' reliance on lecturers' materials rather than self-sourced academic content.

These findings highlight that the success of PjBL implementation depends heavily on the availability of accessible and diverse learning materials. Without sufficient resources, students' ability to explore, analyze, and synthesize knowledge independently remains constrained. Therefore, integrating digital literacy and resource navigation training into the PjBL framework is essential to strengthen students' research autonomy (Bell, 2010; Fisher et al., 2020; Novalia et al., 2025).

Students demonstrated moderate prior knowledge of research methodology and problem-solving strategies, reflecting partial understanding without strong application ability. This corresponds to Binder et al. (2019), who argued that prior knowledge significantly predicts academic achievement but must be deepened through guided practice. The qualitative data revealed that students often felt uncertain about choosing suitable research methods or performing data analysis, reflecting low methodological self-efficacy. One participant stated, "I can write a proposal, but I'm not confident in deciding which method fits my topic." This aligns with Yimer and Ellerton's (2010) view that problem-solving involves not only cognitive but also metacognitive dimensions, such as monitoring and reflection.

Thus, embedding problem-solving phases (engagement, transformation, implementation, evaluation, and internalization) into the PjBL process could help students connect theoretical knowledge to practical applications. By internalizing reflective and metacognitive practices, students can enhance their capacity to

formulate research problems, analyze data critically, and produce meaningful outcomes.

Quantitative data showed that 89.29% of students considered additional support "important," consistent with qualitative findings where students requested more mentoring, workshops, and access to journals. These expectations resonate with Hegde and Karunasagar (2021), who emphasized that building undergraduate research competence requires consistent mentoring, structured supervision, and resource accessibility.

Moreover, DuBois and Keller (2016) stated that PjBL environments must promote not only autonomy but also guided collaboration, ensuring that students receive continuous feedback and scaffolding throughout the research process. Therefore, institutions must create research-supportive ecosystems, including mentoring programs, training on literature review and methodology, and improved access to national and international databases. Such initiatives will strengthen students' confidence, competence, and engagement in independent research.

The initial design of the problem-solving-based inquiry project model was developed from the needs analysis, prior knowledge assessment, and student interviews. Results showed that while students at STKIP Andi Matappa were familiar with project-based learning, they still lacked skills in accessing resources, defining research problems, designing methods, and applying problem-solving in research contexts. Accordingly, the Engagement stage guides students to identify real-world problems through orientation and contextual exploration. The Transformation–Formulation stage involves planning mini research projects where students develop research questions, select methods, and design problem-solving strategies through FGDs and proposal writing.

The Implementation stage focuses on independent data collection and analysis, and the Evaluation stage integrates reflection and peer review to assess and improve research processes and results. Finally, the Internalization stage emphasizes scientific communication—through presentations and report writing—to foster reflection, critical thinking, and the internalization of research-based problem-solving skills.

The initial design of the PjBL model integrated with problem-solving, based on students' needs, includes five stages: orientation (identifying problems), planning (formulating questions and designing methods), investigation (collecting data and reviewing literature), analysis and reflection (analyzing data and evaluating processes), and communication (reporting and presenting findings) (Barrows & Tamblyn, 1980; Bell, 2010; Binder et al., 2019; Fisher et al., 2020; Yimer & Ellerton, 2010)

## 6. Conclusion

To address the research objective, the study identified key student needs underlying the development of a project-based learning (PjBL) model integrated with problem-solving to support independent research. Based on the analysis and

discussion, the students' needs forming the basis for developing a PjBL model integrated with problem-solving include: (1) guidance in accessing learning resources; (2) intensive supervision in research processes; (3) training in academic and technical skills; (4) enhancement of problem-solving abilities; and (5) institutional support through facilities and research access. Based on these key student needs, the initial design of the PjBL model integrated with problem-solving to support independent research consists of the following stages: orientation, planning, investigation, analysis and reflection, and communication.

This study contributes to the development of the PjBL framework by integrating problem-solving principles into its core structure. The results provide empirical support for combining the constructivist learning approach with problem-solving theory (Yimer & Ellerton) to enhance students' research competence and independent learning. The study also reinforces the importance of prior knowledge and contextual needs as foundational elements in educational design, particularly when adopting Plomp's model for instructional innovation.

## 7. Author Contributions

The authors declare that there is no conflict of interest regarding the publication of this paper. Salwah contributed to conceptualization, methodology, formal analysis, supervision, and project administration, and led the preparation of the original draft. Muh Rahmat was responsible for validation, data curation, visualization, and contributed to writing-review and editing. Shindy Ekawati contributed to methodology development, provided resources, and assisted in writing-review and editing. Sry Mulyani, as a student author, carried out investigation and data collection, including transcription, and contributed to the initial draft preparation.

## 8. Acknowledgments

The authors would like to express their sincere gratitude to the Ministry of Higher Education, Science, and Technology of the Republic of Indonesia, under the Directorate General of Research and Development, for the financial support provided through the Regular Fundamental Research Grant Scheme (Contract No. 130/C3/DT.05.00/PL/2025). This support has been instrumental in the successful completion of this research. This research was funded by the Directorate General of Higher Education under grant number.

The authors also wish to acknowledge the use of ChatGPT (OpenAI) in the preparation of this paper. The tool was used solely to assist in improving the clarity, language, and grammar of the manuscript. All ideas, analyses, and conclusions presented in this paper are the authors' own and reflect their original intellectual contributions.

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