Analysis of Science Education Students' Self-Efficacy in Developing Learning Products Through the Project-Based Learning Model

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Received: 19th May 2025; **Accepted**: 20th June 2025; **Published**: 30th June 2025
DOI: https://dx.doi.org/10.29303/jpft.v11i1.9545

***Abstract** - Developing innovative learning products demands high self-efficacy from prospective educators. The Project-Based Learning (PjBL) model offers the potential to develop this competency, yet its impact on the self-efficacy of postgraduate students requires in-depth analysis. This study aims to analyze the self-efficacy levels of Master's students in Science Education in developing learning products (presentations, videos, and a book chapter) implemented through the PjBL model. This study employed a descriptive method with a mixed-methods approach. Data were collected from 11 students through a Likert-scale self-efficacy questionnaire and open-ended responses, then analyzed using descriptive statistics and thematic analysis. The results show that students' overall self-efficacy is high (mean score > 4.18), with slightly higher confidence in asynchronous tasks such as video production (4.24) and writing a book chapter (4.25). The main finding identifies a gap between the very high motivation and growth mindset and the lower self-efficacy in higher-order thinking skills, particularly in data analysis and applying theory to practice (lowest score 3.82). It is concluded that PjBL is effective in building self-efficacy and motivation, while also successfully identifying crucial areas for professional development. Therefore, it is recommended that future PjBL implementation be enriched with more focused guidance on strengthening analytical and synthesis skills to optimize the competencies of future science educators.*

***Keywords:** Self-Efficacy, Project-Based Learning, Science Education, Learning Products, Argumentation Skills*

INTRODUCTION

Education in the 21st century demands a fundamental shift in science teaching practices, moving from mere knowledge transfer to facilitating the development of critical thinking, collaboration, and communication skills. One essential skill highlighted in modern science education is the ability to engage in scientific argumentation (Duschl & Osborne, 2002). This ability is not only crucial for students but has also become a core competency for science educators to design authentic and meaningful learning experiences (Osborne, 2005). This challenge requires teacher education programs, particularly at the postgraduate level, to equip prospective educators with pedagogical competencies that can meet the demands of the times.

In response to this challenge, an educator's success is determined not only by their content mastery but also by their internal belief in their own capabilities. The most relevant psychological construct to explain this is self-efficacy. According to Bandura (1997), self-efficacy refers to an individual's belief in their ability to organize and execute the courses of action required to achieve specific goals. This belief functions as a central mechanism in human agency, significantly influencing choices, effort levels, persistence in the face of difficulties, and emotional resilience (Bandura, 1982).

In the context of science education, teacher self-efficacy is a crucial predictor of teaching quality and its impact on student learning. Teachers with high self-efficacy tend to be more innovative, persistent in assisting struggling students, and more enthusiastic about implementing new teaching approaches (Roberts et al., 2001). Conversely, teachers with low self-efficacy tend to avoid challenging teaching methods and more frequently revert to conventional, lecture-based methods (Bleicher & Lindgren, 2005). Thus, fostering strong self-efficacy in prospective science educators has become an urgent priority in postgraduate education programs.

However, teacher education programs often face challenges in bridging theoretical knowledge with the development of practical confidence. Students may understand various learning design theories but feel uncertain when they must implement them in the form of complex, tangible products, such as instructional videos or academic manuscripts (de Laat & Watters, 1995). This can be attributed to a lack of authentic experiences (*mastery experiences*), which are the primary source of self-efficacy formation (Webb-Williams, 2018). Consequently, postgraduate program graduates may not be fully prepared to innovate in their professional environments, despite possessing a strong theoretical foundation.

As a response to this challenge, the Project-Based Learning (PjBL) model offers a promising solution. PjBL is an instructional approach that places students in an active role to investigate real-world problems and produce concrete, meaningful products. This process inherently provides "mastery experiences," which are the most influential source for building solid self-efficacy (Bandura, 1982). Through PjBL, students do not just learn "about" designing instruction; they directly "do" the designing, producing, and evaluating of learning products.

The application of PjBL for Master's students in Science Education becomes increasingly relevant as the assigned tasks—such as creating video presentations and writing a book chapter—demand the integration of various higher-order skills. To produce high-quality products, students must be able to construct coherent arguments, a process closely linked to critical thinking and self-efficacy (Yıldız-Feyzioğlu & Kıran, 2022). Therefore, PjBL has the potential not only to enhance self-efficacy in technical aspects but also in deeper cognitive aspects, such as the ability to argue scientifically (Faize et al., 2017).

Although many studies have examined the effectiveness of PjBL or the importance of self-efficacy separately, a research gap still exists regarding how the PjBL model specifically influences the self-efficacy of postgraduate Science Education students in the process of developing various types of modern learning products. This investigation is essential to provide empirical evidence on the effectiveness of PjBL as a pedagogical model in higher education and to identify areas of strength and weakness in student self-efficacy, which can serve as a basis for future curriculum refinement.

Therefore, this study aims to conduct an in-depth analysis of the self-efficacy levels of Master's students in Science Education in designing, implementing, and evaluating learning products, including live presentations, video presentations, and a book chapter. Specifically, this research will identify trends in self-efficacy for each task type, map the aspects with the highest and lowest self-efficacy, and provide insights for improving the implementation of the Project-Based Learning model in the future.

RESEARCH METHOD

This study employed a mixed-methods approach with a descriptive design. This approach was chosen to obtain a comprehensive understanding of students' self-efficacy levels, where quantitative data served as the primary data for measurement, while qualitative data were used to enrich and deepen the interpretation of the findings. The research was conducted within the context of the "Instructional Design in Science" course, which implements the Project-Based Learning (PjBL) model as its main pedagogical framework. The research subjects were 11 students from the Master's Program in Science Education enrolled in the course, selected using a total sampling technique.

The main instrument used for data collection was a self-efficacy questionnaire developed based on the three main products in the PjBL model. The questionnaire consisted of 27 statement items divided into three sections: (1) Self-efficacy in Task 1: Live Presentation, (2) Self-efficacy in Task 2: Video Presentation, and (3) Self-efficacy in Task 3: Paper/Chapter. Each item was measured using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) to assess students' level of confidence. Additionally, the instrument included open-ended questions to gather qualitative data regarding students' perceptions, experiences, and reflections during their project-based learning.

Data analysis was conducted in an integrated manner to address the research objectives. Quantitative data from the questionnaire were analyzed using descriptive statistics to calculate the mean score for each item and each task section. This analysis aimed to identify general trends, compare self-efficacy levels across different task types, and map areas of strength (highest scores) and weakness (lowest scores). Meanwhile, qualitative data from the open-ended responses were analyzed using thematic analysis to identify emerging patterns and themes. The results from both analyses were then synthesized (data triangulation) to provide a holistic overview and a richer interpretation of student self-efficacy within the PjBL context.

RESULTS AND DISCUSSION

This section presents the research findings on the self-efficacy levels of Science Education students in developing learning products through the PjBL model. The quantitative results from the questionnaire will be presented first, followed by an in-depth discussion that integrates the findings with theoretical frameworks and previous research.

Research Findings

1. Overall Picture of Students' Self-Efficacy Levels

Descriptive statistical analysis shows that students generally possess a high level of self-efficacy across all three project-based tasks. The overall mean score for each section is as shown in Figure 1.

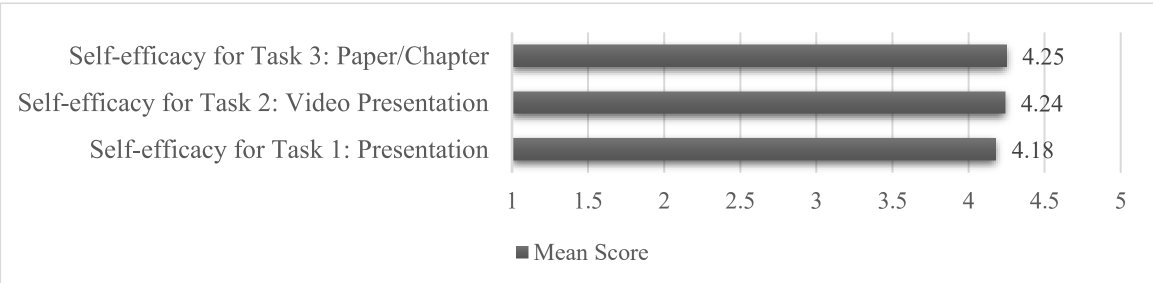

Figure 1. Comparison of Mean Self-Efficacy Scores Across Different Task Types.

This data indicates that students' self-confidence falls within the "High" category (score > 4.0), with a slight tendency towards higher confidence in asynchronous tasks (video and paper) that allow for revision and refinement.

2. Identification of Areas of Strength and Weakness (Data Trends)

A more in-depth analysis of each item reveals a significant trend. There is a clear gap between self-efficacy in motivational aspects and self-efficacy in higher-order cognitive skills.

- **Areas of Strength (Highest Scores):** Items related to motivation, growth mindset, and the desire to improve showed very high mean scores.
  - "I want to improve my skills..." (Items 9, 17, 26): Score 4.82 - 4.91
  - "I am confident I can create/write... a better product in the next assignment" (Items 18, 27): Score 4.91

- **Areas for Improvement (Lowest Scores):** Conversely, items measuring deep analytical and synthesis skills showed the lowest mean scores in the survey.
  - "I am satisfied with my ability to answer audience questions" (Item 8): Score 3.82
  - "I feel confident that I can analyze and interpret research results accurately" (Item 22): Score 3.82
  - "I feel confident that I can connect theory to practice in my paper/article" (Item 23): Score 3.82.

3. Analysis of Open-Ended Responses

To deepen the understanding of the quantitative findings, a thematic analysis was conducted on the qualitative data from students' open-ended responses. This analysis identified four main themes that provide context for the high self-efficacy scores and confirm the effectiveness of the Project-Based Learning (PjBL) model from the students' perspective. These themes are presented below.

- **Contextual Relevance and Pedagogical Innovation.**

Students consistently appreciated the course design's relevance to their professional needs and its real-world applicability. They perceived that up-to-date materials and innovative methods directly contributed to their understanding and confidence. This is reflected in a respondent's statement:

> *"I appreciate the in-depth approach to various theories and practices relevant to developing learning strategies... This not only enriches our understanding but also motivates us to keep up with the latest developments in the field."* (Respondent B).

This appreciation for relevance indicates that when students see the direct utility of what they are learning, their belief in their ability to apply that knowledge—a core component of self-efficacy—also increases.

- **The Role of the Instructor as a Source of Verbal Persuasion**

The role of the instructor as a facilitator and motivator emerged as a very strong theme. Positive feedback, an interactive teaching style, and a supportive learning environment were explicitly mentioned as factors that boosted morale and self-confidence. One response clearly illustrates this:

> *"With the guidance of a humorous, devout, and creative instructor, new enthusiasm is always cultivated when the battery of our spirit starts to run low (lowbat)..."* (Respondent H).

Support like these functions as *verbal persuasion*, one of the main sources of self-efficacy formation according to Bandura's theory. Encouragement and constructive feedback from a trusted figure convince students that they have the capability to succeed.

- **The Project as a Mastery Experience**

Students clearly acknowledged that the process of working on the project tasks—though challenging—directly improved their various practical skills. The experience of completing a project from start to finish became tangible proof of their abilities, which constitutes a *mastery experience*. One respondent stated:

> *"The various meetings and tasks in this course have significantly improved our wide range of skills and abilities, from communication, creating PPT, collaboration, writing, and much more."* (Respondent I).

This direct experience in completing complex tasks and producing concrete products (video and book chapter) becomes the most potent source of self-efficacy, as it provides authentic evidence of their competence.

- **Technology as a Facilitator and Learning Support.**

The final theme that emerged was the positive perception of technology use in the course. Technology was seen not just as a tool but as a facilitator that simplified the learning and project-completion process, thereby reducing technical barriers that could lower self-confidence. This was expressed by a respondent:

> *"Additionally, the use of technology in the classroom greatly supports the learning process, making it easier for students."* (Respondent J).

When students feel supported by adequate technology, they can focus more on content and creativity, which in turn enhances their confidence in producing high-quality work.

Discussion

Effectiveness of PjBL in Building a Foundation for Self-Efficacy

The high overall self-efficacy scores (mean > 4.18) provide strong evidence that the Project-Based Learning (PjBL) model successfully created a supportive learning environment. This finding aligns with Bandura & Wessels' (1997) theory of self-efficacy, which states that *mastery experiences* are the most influential source of self-belief. By working on real projects from inception to completion, students directly experience the processes of designing, producing, and evaluating, which builds their confidence (Bandura, 1982). This is crucial, as high teacher self-efficacy is positively correlated with more innovative and persistent teaching practices (Roberts et al., 2001) and reduces the tendency to revert to conventional methods (Bleicher & Lindgren, 2005).

The trend of slightly higher confidence in asynchronous tasks (video and paper) can be interpreted as an effect of greater autonomy and control afforded to the students. Unlike live presentations that demand spontaneous performance, asynchronous tasks allow students to revise, edit, and perfect their work until they are satisfied. Such an environment of control can reduce anxiety and increase confidence, similar to how informal science centers successfully boost self-efficacy by providing safe, non-judgmental exploratory environments (Sasson, 2014; Lane et al., 2013). This experience offers a solution to the problem identified by de Laat & Watters (1995), where students often feel uncertain about applying theory to practice.

The Self-Efficacy Gap: High Motivation vs. the Challenge of Scientific Argumentation

The most significant finding of this study is the revealed gap between students' very high intrinsic motivation and their lower self-confidence in complex cognitive skills. The near-perfect scores on items related to the "desire to improve" indicate that PjBL successfully fostered a growth mindset and a positive professional disposition. However, the lowest scores on items involving analysis, interpretation, and connecting theory to practice signal a fundamental challenge. These skills are at the core of **scientific argumentation** (Duschl & Osborne, 2002; Jiménez-Aleixandre & Erduran, 2007).

Argumentation in science is not merely about stating a claim but about providing justification, evaluating evidence, and linking data to a theoretical framework (Faize et al., 2017; Osborne, 2005). Students' difficulty in feeling confident in these areas can be interpreted as low self-efficacy in constructing and presenting strong scientific arguments, both orally (answering audience questions) and in writing (in their papers). This is a complex challenge, as it requires mastery of dialectics and argument structure (Bricker & Bell, 2008; Nielsen, 2013). Research by Yıldız-Feyzioğlu & Kıran (2022) demonstrates a relationship between self-efficacy for argumentation and critical thinking skills, which reinforces the interpretation of this finding.

Pedagogical Implications: Strengthening Argumentation within the PjBL Framework

This finding does not imply that PjBL failed; on the contrary, the model has successfully served as an effective diagnostic tool to precisely map students' learning needs. PjBL has built a solid motivational foundation, and the next step is to enrich this framework with more explicit interventions. Research by Ogan-Bekiroglu & Aydeniz (2013) and Fettahlioglu (2018) shows that teacher self-efficacy in teaching argumentation can be enhanced through experience and modeling. Therefore, future PjBL courses should intentionally integrate *scaffolding* sessions focused on developing argumentation skills.

This strategy could include modeling how to analyze data (Boettcher & Meisert, 2011), workshops on constructing argument frameworks, and structured exercises in evaluating scientific claims. This approach aligns with recommendations for improving the pedagogy of argumentation in science classrooms (Özdem Yilmaz et al., 2017). It is important to note, as shown by Lytzerinou & Iordanou (2020), that the actual ability to argue and *perceived self-efficacy* are two different things, so interventions must target both. Thus, an enriched PjBL will not only increase students' general self-efficacy (Webb-Williams, 2018; Dorfman & Fortus, 2019) but also specifically build *self-efficacy for argumentation* (Kıran & Feyzioğlu, 2021), preparing them to be truly competent science educators. The use of validated and carefully analyzed instruments, as advocated by Boone et al. (2011), will remain key to monitoring the effectiveness of these interventions.

CONCLUSION

Based on the analysis and discussion, it can be concluded that the implementation of the Project-Based Learning (PjBL) model effectively enhanced the self-efficacy of Master's students in Science Education in developing various learning products. Students demonstrated a high level of self-confidence overall, particularly in tasks that offered flexibility, such as video production and book chapter writing. More importantly, the model successfully cultivated a strong intrinsic motivation and growth mindset among the students. However, this study also identified specific challenges in the area of higher-order thinking skills, where students felt less confident in analyzing data, interpreting results, and connecting theory with practice.

Based on these conclusions, several suggestions are proposed for the future refinement of PjBL implementation. First, it is recommended that the course explicitly integrate workshop sessions or focused guidance on strengthening data analysis skills and the construction of scientific arguments. Second, instructors can provide more concrete examples (modeling) and detailed assessment rubrics, especially for the analysis and discussion sections, to offer clearer guidance to students. By enriching the PjBL framework with these targeted interventions, it is hoped that the postgraduate program will not only produce motivated educators but also professionals who are competent and confident in applying the essential analytical skills required in modern science education.

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