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Fostering Leadership Competency for High School Students through STEM Project-Based Learning: *A Survey Study*

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Abstract

This study aims to investigate teachers' perceptions of the potential of STEM project-based learning (PBL) to foster leadership competency in high school students in Vietnam. The current educational reform context requires equipping students with 21st-century skills, in which leadership is a core competency that is often not systematically nurtured within the formal curriculum. The main research method was a questionnaire survey administered to 50 high school teachers with diverse experience. The questionnaire was designed to assess four aspects: (1) perceptions of STEM education, (2) the current status of STEM project implementation, (3) the necessity of fostering leadership competency, and (4) the potential of a specific STEM project ("Smart Greenhouse") to develop leadership competency. Data were analyzed using descriptive statistics, and the scale's reliability was confirmed with a Cronbach's Alpha coefficient of 0.728. The results show that teachers have a very positive perception of the role of STEM education (M = 4.32 for understanding its importance) and clearly recognize the need for leadership development among students (M = 4.44). However, leadership development programs at the school level are limited (M = 3.66). Notably, teachers highly rated the "Smart Greenhouse" project's ability to develop foundational skills such as project management (M = 4.26) and teamwork (M = 4.24), and believe the project can foster overall leadership competency in students (M = 4.10). It is concluded that STEM PBL is a feasible and teacher-supported method for integrating leadership development into teaching activities, thereby addressing a significant gap in current secondary education.

Keywords:

STEM Education; Leadership Competency; Project-Based Learning; High School Students; Smart Greenhouse.

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1. Introduction

The contemporary world, profoundly shaped by the dynamics of the Fourth Industrial Revolution, demands a fundamental transformation in education. The focus is shifting from rote memorization of content to the cultivation of versatile competencies essential for navigating complexity and driving innovation (Prime Minister, 2017). Consequently, educational systems globally are being reformed to equip students with 21st-century skills, such as critical thinking, collaboration, creativity, and particularly, leadership (Partnership for 21st Century Skills, n.d.). Leadership, defined as a process of influencing a group to achieve a common goal (Northouse, 2021), is no longer considered an innate trait reserved for a select few but a learnable competency crucial for personal development and societal progress. This paradigm shift necessitates pedagogical approaches that can effectively foster these skills within the fabric of formal schooling.

In response to this imperative, STEM (Science, Technology, Engineering, and Mathematics) education has emerged as a central pillar of educational reform worldwide. Its historical impetus can be traced to concerns over national economic competitiveness and scientific advancement (National Commission on Excellence in Education, 1983; Roberts, 2012). Modern STEM education, however, transcends the teaching of its constituent subjects in isolation. It advocates for an integrated, interdisciplinary approach where academic concepts are interwoven with real-world applications, enabling students to solve authentic problems (Sanders, 2009; NRC, 2014). To operationalize this vision, Project-Based Learning (PBL) has been widely recognized as a highly effective pedagogy. With philosophical roots in the "learning by doing" principle championed by John Dewey (1916, 1938) and systematically articulated by William H. Kilpatrick (1918), PBL engages students in extended, inquiry-based projects centered on complex questions or challenges (Thomas, 2000). This method promotes deep learning and skill development as students work collaboratively to create tangible, meaningful products (Bybee, 2013; Larmer & Mergendoller, 2010).

The Vietnamese education system is actively embracing these global trends. Acknowledging the need to prepare a high-quality workforce, the government has emphasized the importance of strengthening capacity for the Fourth Industrial Revolution (Prime Minister, 2017). This commitment is institutionalized in the landmark 2018 General Education Curriculum, which officially shifts the educational focus from content transmission to competency development (MOET, 2018). To provide concrete guidance, the Ministry of Education and Training (MOET) issued Official Letter No. 3089, which details the implementation of STEM education in secondary schools, explicitly encouraging project-based approaches (MOET, 2020). While significant progress has been made in integrating STEM, its nationwide implementation still faces challenges, including the need for enhanced teacher professional development and adequate resources (Nguyen, T. N. et al., 2022; Tran & Nguyen, 2021).

Despite the strong policy support for competency-based education, a notable gap persists in the systematic cultivation of leadership skills within the mainstream curriculum.

While the importance of leadership is acknowledged, its development is often confined to extracurricular activities, lacking a structured pedagogical framework integrated into core subjects (Nguyễn Quang Linh & Cao Tiến Khoa, 2024). This leaves a critical disconnect between the educational goal of forming well-rounded, capable individuals and the practical learning experiences offered in the classroom. This study addresses this gap by exploring the potential of STEM PBL as a viable model for embedding leadership development directly into the high school science curriculum.

This paper investigates the perceptions of high school teachers regarding the potential of a specific STEM project—the "Smart Greenhouse"—to foster leadership competency among 11th-grade Physics students. The primary objectives are: (1) to assess teachers' current understanding of STEM education and their views on the necessity of leadership development, and (2) to evaluate their professional judgment on the effectiveness of the proposed STEM project for developing specific leadership skills. This paper is organized as follows: the Materials and Methods section details the survey design and participants. Subsequently, the Results and Discussion section presents and interprets the empirical findings from the teacher survey. Finally, the Conclusion summarizes the key findings and discusses their implications for integrating leadership development into STEM education in Vietnam.

2. Materials and Methods

2.1. Research Design

This study employed a descriptive survey research design. This quantitative approach was selected to systematically collect and analyze data regarding the perceptions, attitudes, and current practices of high school teachers. The primary goal was to create a detailed snapshot of the current landscape concerning STEM education and leadership development in Vietnamese high schools, thereby providing an empirical basis for the research problem.

2.2. Participants and Procedure

The target population for this study comprised high school Physics teachers in Vietnam. A total of 50 teachers participated in the survey. Participants were selected through a random sampling method. A Google Form link to the survey was distributed in various Zalo (a popular messaging application in Vietnam) groups dedicated to Physics teachers. The data collection period was conducted from December 24, 2024, to December 30, 2024. The demographic profile of the participants is as table 1:

Table 1. Summary Table of Survey Participant Characteristics

Characteristic	Category	Frequency (n)	Percent (%)
Gender	Male	24	48.0
	Female	26	52.0
Years of Service	Under 5 years	2	4.0
	5 to 10 years	7	14.0
	Over 10 years	41	82.0
Educational Level	Bachelor	43	86.0
	Master	7	14.0

The sample was well-balanced, with 24 male (48.0%) and 26 female (52.0%) teachers.A majority of the respondents were highly experienced, with 41 teachers (82.0%) having over 10 years of experience. Seven teachers (14.0%) had 5-10 years of experience, and two teachers (4.0%) had less than 5 years of experience.Most participants held a Bachelor's degree (43 teachers, 86.0%), while seven teachers (14.0%) had attained a Master's degree.

2.3. Research Instruments

Two main instruments underpinned this research: a survey questionnaire and a theoretical leadership framework.

2.3.1. Survey Questionnaire

The primary data collection tool was a structured questionnaire designed to address the research objectives. It consisted of demographic questions and 13 core items organized into four main sections:

- Teachers' Perception and Attitude toward STEM Education: Questions assessing teachers' understanding of and belief in the importance of STEM (e.g., Q1, Q2).
- Current State of STEM Project Implementation: Questions investigating the frequency of STEM projects at schools and teachers' involvement (e.g., Q4, Q5).
- Necessity of Fostering Leadership Competency: Questions gauging teachers' views on the need for leadership development and the existence of relevant school programs (e.g., Q7, Q9).
- Potential of the "Smart Greenhouse" STEM Project: Questions evaluating the specific project's potential to develop skills related to leadership, such as teamwork and project management (e.g., Q10, Q12, Q13).

All core items were measured on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The project context provided in the survey described the "Smart Greenhouse" as a hands-on task where students would design and build a model using sensors to create optimal growing conditions, with the explicit goal of fostering leadership through teamwork, problem-solving, and project management.

2.3.2. Theoretical Framework

The study's conceptualization of student leadership was grounded in the Leadership Competency Framework for High School Students developed by Nguyễn Quang Linh and Cao Tiến Khoa (2024). This framework was selected due to its recent development, its specific focus on the Vietnamese high school context, and its construction through a rigorous Delphi method with educational experts. The framework operationalizes leadership into six core, measurable components: (1) Strategic thinking, (2) Effective communication, (3) Management and delegation, (4) Problem-solving and decision making, (5) Motivation and team encouragement, and (6) Ethics and social responsibility. This framework provided the theoretical lens through which the potential of the STEM project was evaluated.

2.4. Data Analysis

Data collected from the Google Form were compiled and analyzed using statistical methods. Descriptive statistics, including frequencies, percentages, mean scores, and standard deviations, were calculated for all items to summarize the teachers' responses. The internal consistency and reliability of the 13-item survey scale were assessed using Cronbach's Alpha to ensure the validity of the measurement instrument.

3. Results and Discussion

This section presents the findings from the teacher survey and discusses their implications in the context of the research objectives and theoretical framework.

3.1. Results

3.1.1. Reliability of the Survey Instrument

Before analyzing the main findings, the reliability of the 13-item questionnaire was assessed to ensure the internal consistency of the measurement scale. The analysis yielded a Cronbach's Alpha coefficient of 0.728. As this value is above the commonly accepted threshold of 0.70, the survey instrument is considered reliable and suitable for data analysis.

Table 4. Cronbach's Alpha Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.728	.760	13

Furthermore, an item-total statistics analysis was conducted. The results indicated that the Cronbach's Alpha value would not increase significantly if any single item were removed, with values ranging from 0.683 to 0.750. This confirms that all items contributed positively to the overall consistency of the scale.

Table 6. Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q1	48.8400	23.811	.426	.857	.704
Q2	49.0200	22.183	.586	.787	.683
Q3	49.1200	24.067	.645	.634	.696
Q4	48.9400	23.037	.555	.699	.691
Q5	49.0000	22.857	.526	.744	.692
Q6	49.1200	23.210	.318	.419	.716
Q7	49.5400	21.641	.374	.668	.712
Q8	48.7200	25.553	.193	.590	.727
Q9	49.5000	21.194	.432	.730	.701
Q10	48.9200	23.218	.360	.628	.710
Q11	49.2400	25.737	.057	.323	.750
Q12	48.9000	25.357	.183	.682	.729
Q13	49.0600	25.323	.196	.706	.727

3.1.2. Descriptive Statistics of Teacher Perceptions

The descriptive statistics for the 13 survey questions, including mean scores and standard deviations, are summarized in the table below. The mean scores reflect the central tendency of teachers' attitudes on a 5-point Likert scale.

Table 5. Item Statistics of Survey Questions

	Mean	Std. Deviation	N
Q1	4.3200	.68333	50
Q2	4.1400	.78272	50
Q3	4.0400	.44994	50
Q4	4.2200	.67883	50
Q5	4.1600	.73845	50
Q6	4.0400	.96806	50
Q7	3.6200	1.17612	50
Q8	4.4400	.61146	50
Q9	3.6600	1.15370	50
Q10	4.2400	.89351	50
Q11	3.9200	.92229	50
Q12	4.2600	.69429	50
Q13	4.1000	.67763	50

The results are detailed below according to the four thematic sections of the questionnaire.

Teachers' Perception and Attitude toward STEM Education

The findings indicate a highly positive perception of STEM education among teachers. There was strong agreement with the statement, "I clearly understand the concept and importance of STEM education" (Q1, M=4.32, SD=0.68333). Similarly, teachers strongly believed that "STEM education is necessary for students' holistic development" (Q2, M=4.14, SD=0.78272). However, there was slightly less confidence regarding personal capabilities, as shown in the response to "I have sufficient knowledge and skills to implement STEM projects in teaching" (Q3, M=4.04, SD=0.44994). The low standard deviation for Q3 suggests a consistent, moderate level of self-perceived competence among the respondents.

Current State of STEM Project Implementation

Teachers reported that STEM projects are being actively implemented in their schools. They largely agreed with the statement, "My school frequently organizes STEM projects for students" (Q4, M=4.22, SD=0.67883). This is reinforced by their high level of personal involvement, as reflected in the response to "I have participated in or organized STEM projects for students" (Q5, M=4.16, SD=0.73845). However, the results suggest that student engagement could be a challenge, as the mean score for "STEM projects organized at my school often have active student participation" was slightly lower (Q6, M=4.04), with a notably higher standard deviation (SD=0.96806), indicating varied experiences with student engagement levels.

Necessity of Fostering Leadership Competency

The survey revealed a strong consensus on the need for leadership development. The highest-rated item in the entire survey was "I notice that my students have a need to develop leadership competency" (Q8, M=4.44, SD=0.61146). In stark contrast, responses to statements about the practical implementation of leadership training were significantly lower. The mean score for "The fostering of leadership competency for students is necessary" (Q7) was 3.62 (SD=1.17612), and for "My school already has programs or activities to develop leadership competency for students" (Q9) was 3.66 (SD=1.15370). The high standard deviations for Q7 and Q9 suggest a wide diversity of opinions and situations across different schools.

Potential of the "Smart Greenhouse" STEM Project

Teachers evaluated the proposed "Smart Greenhouse" project very favorably as a tool for developing leadership-related skills. There was strong agreement that the project could help students develop project management skills (Q12, M=4.26, SD=0.69429) and teamwork skills (Q10, M=4.24, SD=0.89351). The potential to develop problem-solving skills was also viewed positively (Q11, M=3.92, SD=0.92229). Crucially, teachers expressed confidence that the project could achieve its overarching goal, with a high mean score for "I believe that the 'Smart Greenhouse' project can foster leadership competency for students" (Q13, M=4.10, SD=0.67763).

3.2. Discussion

The results of the survey provide valuable insights into teachers' perspectives on the intersection of STEM education and leadership development in Vietnamese high schools. The discussion will focus on three key themes emerging from the data: the alignment of teacher perceptions with national policy, the critical gap between the need for and provision of leadership training, and the potential of STEM PBL as a practical solution.

First, the findings demonstrate that teachers have a positive and well-informed understanding of STEM education. This high level of awareness aligns with the national strategic direction set by government policies such as Directive 16/CT-TTg and the 2018 General Education Curriculum, which aim to enhance STEM capacity and promote competency-based learning. This widespread teacher buy-in is a crucial foundation for the successful implementation of innovative pedagogical approaches like STEM PBL.

Second, the most striking finding is the significant disconnect between the perceived need for leadership development and its actual implementation in schools. Teachers overwhelmingly recognize that students need leadership skills (M=4.44) , yet they report a lack of formal programs to address this need (M=3.66). This gap highlights a critical area for improvement in the current educational landscape. It suggests that while the curriculum aims for holistic development, there is a shortage of practical, integrated models for fostering essential soft skills like leadership within the formal school day.

This leads to the third and most important theme: the perceived potential of the "Smart Greenhouse" project as a viable solution to this problem. Teachers' strong belief that this project can foster teamwork, project management, and overall leadership is not arbitrary. It aligns directly with the mechanisms of STEM PBL, which create an authentic learning environment that necessitates the use of leadership skills. The project's structure, which mirrors the Engineering Design Process, requires students to engage in behaviors central to the leadership framework used in this study (Nguyễn Quang Linh & Cao Tiến Khoa, 2024). For instance, planning and executing the project develops "Strategic thinking"; collaborating in groups fosters "Effective communication" and "Management and delegation" ; and overcoming technical challenges develops "Problem-solving and decision making".

However, the results also signal areas that require attention. The slight lack of confidence teachers feel in their own ability to implement STEM projects (Q3) indicates a need for targeted and continuous professional development, a challenge noted in previous research on STEM in Vietnam. Furthermore, the varied experiences with student engagement (Q6) suggest that for STEM projects to be effective, they must be carefully designed to be authentic and motivating for all students, ensuring active rather than passive participation.

In conclusion, the discussion of these results suggests that while challenges remain, there is strong support among teachers for using STEM PBL as a vehicle for leadership development. The "Smart Greenhouse" project serves as a promising model that addresses a

clearly identified gap in the Vietnamese educational system, providing a practical pathway to integrate the development of critical 21st-century competencies into subject-based teaching.

4. Conclusion

This study set out to investigate the perceptions of Vietnamese high school teachers regarding the use of STEM project-based learning (PBL) as a method for fostering student leadership competency. The research findings confirm that teachers hold a significantly positive and well-informed view of STEM education, recognizing its importance and necessity for the holistic development of students. The data indicates that STEM projects are being implemented with a fair degree of regularity in schools, and teachers are actively participating in these initiatives. The reliability of the survey instrument used to gather these insights was validated with an acceptable Cronbach's Alpha coefficient of 0.728, ensuring the consistency of the results.

The most critical conclusion drawn from this research is the identification of a significant gap between the recognized need for leadership skills and the current educational provisions to develop them. Teachers reported overwhelmingly that their students have a clear and present need to develop leadership competency, viewing it as a vital element of their education. However, the findings simultaneously reveal a stark lack of formal programs or structured activities designed to foster this competency within their schools. This disconnect highlights a systemic challenge where a crucial 21st-century skill is desired in principle but is not yet being systematically cultivated in practice.

In response to this identified gap, this study concludes that STEM PBL presents a highly promising and practical solution. The participating teachers strongly endorsed the potential of a well-designed STEM project, specifically the "Smart Greenhouse" model, as an effective vehicle for fostering leadership. Their professional judgment indicates a firm belief that such projects can successfully cultivate essential leadership-related skills, including teamwork, problem-solving, and project management. This strong support is grounded in the understanding that the authentic, collaborative, and inquiry-based nature of STEM projects creates a natural training ground for students to apply and develop leadership behaviors in a meaningful context.

Ultimately, the implications of this study are clear and actionable. The findings provide empirical evidence encouraging educational policymakers and school leaders to advocate for the wider integration of STEM projects into the formal curriculum. This approach serves a dual purpose: delivering core subject knowledge while simultaneously and systematically developing essential soft skills. Furthermore, the results suggest that teacher professional development should extend beyond technical STEM skills to include training on how to design and facilitate projects that intentionally create opportunities for leadership growth. This research affirms that fostering student leadership is an attainable goal, achievable through practical and engaging pedagogical strategies that contribute to the comprehensive development of students for their future endeavors.

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