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FOSTERING LEADERSHIP CAPACITY FOR HIGH SCHOOL STUDENTS THROUGH THE STEM PROJECT "SMART CLOTHES RACK" IN TEACHING PHYSICS 11

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Abstract

This paper presents the results of a study on teachers' perceptions and attitudes regarding the fostering of leadership capacity for students through the "Smart Clothes Rack" STEM project in the Physics 11 curriculum. The study employed a quantitative survey method, with a 13-item questionnaire administered to 33 practicing teachers. The collected data were analyzed using descriptive statistics and Cronbach's Alpha reliability analysis. The results indicate that teachers have a positive perception of the importance of STEM education and recognize a genuine need among students for leadership development; however, specific programs in schools are limited. The "Smart Clothes Rack" project was highly rated by teachers for its potential to develop teamwork skills (M=4.0303), problem-solving skills (M=4.0303), project management skills (M=4.1818), and overall leadership capacity (M=3.9697). The study concludes that implementing well-designed STEM projects with clear objectives, such as the "Smart Clothes Rack," is an effective and feasible method for integrating leadership development into the teaching process, contributing to the holistic development of students.

Keywords:

STEM education; leadership capacity; project-based learning; Physics education; teacher perception.

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1. Introduction

In the context of Vietnam's education system undergoing a strong transformation toward competency development, equipping students with 21st-century skills has become an urgent requirement. To meet this demand, STEM (Science, Technology, Engineering, and Mathematics) education is increasingly emphasized as an interdisciplinary approach that helps learners apply knowledge to solve practical problems(Akcan et al., 2023; Arshad, 2021). The current state of STEM implementation in high schools has been documented in various studies, such as in Thai Nguyen province(Asunda, 2018; Bozkurt Altan & Tan, 2021). However, leveraging STEM projects not only to reinforce knowledge but also to cultivate specific soft skills like leadership capacity remains an area that requires deeper research(Arshad, 2021; Bennett et al., 2021).

This study was conducted on the topic: "Fostering leadership capacity for students through the STEM project 'Smart Clothes Rack' in teaching Physics 11". The overall objective of the research is to comprehensively understand the issue from the teachers' perspective, including surveying their perceptions and attitudes towards STEM education, the current state of project implementation in schools, and the necessity of fostering leadership capacity for high school students. The core focus of the study is to evaluate the potential for developing students' leadership capacity through their direct participation in the proposed STEM project.

To achieve this objective, a specific learning project named the "Smart Clothes Rack" was designed. In this project, students are tasked with designing and building a model of a clothes rack using rain and light sensors. This model must operate intelligently, meaning it automatically extends the clothes to dry in favorable weather conditions (daytime, no rain) and retracts them at night or when it rains. Beyond the academic goals related to Physics knowledge, the core pedagogical purpose of the project is "to foster leadership capacity for students". This capacity is expected to be formed and developed through interactive activities during the project's execution, including the cultivation of teamwork, problem-solving, and project management skills. By analyzing teacher evaluations, this study will provide practical evidence of the potential of integrating leadership development goals into a specific STEM project, thereby contributing scientific arguments for innovating teaching methods in Vietnam.

2. Research Methodology

This study was conducted using a quantitative survey method to systematically collect and analyze data on teachers' perceptions and attitudes. The survey participants were 33 teachers, including 19 female teachers (57.6%) and 14 male teachers (42.4%). A notable characteristic of the sample is that the majority of teachers have extensive teaching experience, with 28 individuals (84.8%) having more than 10 years of service. Regarding academic qualifications, 26 teachers (78.8%) hold a Bachelor's degree, and 7 teachers (21.2%) hold a Master's degree.

The primary data collection tool was a pre-designed questionnaire titled "QUESTIONNAIRE FOR TEACHERS" (see Appendix 1 for details). This instrument consists of 13 main questions structured into four content sections: (1) Teachers' perceptions and attitudes towards STEM education; (2) The current state of implementing STEM projects in teaching; (3) The necessity of fostering and developing leadership capacity for students in high school ; and (4) The potential for developing students' leadership capacity through the "Smart Clothes Rack" STEM project. All questions measuring opinions use a 5-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree".

Data collected from the questionnaires were coded and processed using specialized statistical software. The analysis process included two main techniques. First, descriptive statistics were used to calculate indicators such as frequency, percentage, mean (M), and standard deviation (SD) to summarize the sample's characteristics and the general trend of teachers' opinions. Second, the Cronbach's Alpha coefficient was calculated to perform a reliability analysis, thereby assessing the internal consistency of the scale used in the study.

3. Results

3.1. Reliability Analysis of the Scale

To ensure the quality of the measurement tool, the reliability of the questionnaire was tested using Cronbach's Alpha.

Table 1: Cronbach's Alpha Evaluation

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.637	.671	13

The results from Table 1 show that the overall Cronbach's Alpha for the 13 items is 0.637. According to standards in social science research, a coefficient above 0.6 can be considered acceptable, indicating that the scale has a basic level of internal consistency.

Table 2: Item-Total Statistics from the Questionnaire

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q1	48.6364	22.551	.402	.820	.601
Q2	48.8182	21.528	.507	.726	.582
Q3	48.9091	22.335	.555	.703	.588
Q4	48.7273	21.330	.578	.847	.574
Q5	48.7576	21.564	.482	.708	.585
Q6	48.8182	23.091	.214	.359	.628
Q7	49.3030	20.405	.353	.805	.603

Q8	48.6364	22.426	.364	.738	.604
Q9	49.3636	20.801	.311	.795	.613
Q10	48.9394	21.309	.381	.653	.597
Q11	48.9394	26.246	-.124	.277	.680
Q12	48.7879	26.235	-.119	.528	.674
Q13	49.0000	25.813	-.077	.378	.673

A deeper analysis of the item-total correlation (Table 2) reveals that some items contributed positively and strongly to the scale, especially those related to STEM perception and status, such as Q4 (0.578), Q3 (0.555), and Q2 (0.507). However, the analysis also identified some items with low or negative correlations with the total score, specifically Q11 (-0.124) and Q12 (-0.119), suggesting that these items may not measure the same construct as the others. Notably, removing item Q11 or Q12 could increase the overall Cronbach's Alpha to 0.680 and 0.674, respectively. This suggests that the scale's reliability could be improved if these items were revised or removed in future research.

3.2. Survey Results on Perceptions, Attitudes, and Current State

Table 3: Item Statistics from the Questionnaire

	Mean	Std. Deviation	N
Q1	4.3333	.73598	33
Q2	4.1515	.79535	33
Q3	4.0606	.60927	33
Q4	4.2424	.75126	33
Q5	4.2121	.81997	33
Q6	4.1515	.93946	33
Q7	3.6667	1.24164	33
Q8	4.3333	.81650	33
Q9	3.6061	1.24848	33
Q10	4.0303	1.01504	33
Q11	4.0303	.88335	33
Q12	4.1818	.80834	33
Q13	3.9697	.88335	33

The descriptive statistics from Table 3 clearly reflect teachers' views on various aspects of STEM education and leadership capacity. Regarding perceptions and attitudes,

teachers showed a high degree of consensus, agreeing that they have a clear understanding of the concept and importance of STEM education (Q1: M = 4.3333) and believe that STEM is necessary for the holistic development of students (Q2: M = 4.1515). They also expressed confidence in their own knowledge and skills to implement STEM projects (Q3: M = 4.0606).

Regarding the current state of implementation, teachers reported that their schools frequently organize STEM projects (Q4: M = 4.2424) and that they have personally participated in or organized these activities (Q5: M = 4.2121). Student participation in these projects was also rated as quite positive (Q6: M = 4.1515).

Concerning the necessity of developing leadership capacity, teachers perceive it as an important factor (Q7: M = 3.6667) and observe a need for this skill development among students (Q8: M = 4.3333). However, the mean score for the question about whether schools have specific programs for leadership development was quite low (Q9: M = 3.6061), indicating a gap between the perceived need and the practical implementation in schools.

3.3. Assessment of the "Smart Clothes Rack" Project's Potential

The final part of the survey focused on teachers' assessment of the "Smart Clothes Rack" project's potential to develop student skills. Overall, the project was evaluated very positively. Teachers believe that this project can help students develop teamwork skills (Q10: M = 4.0303) and problem-solving skills (Q11: M = 4.0303). Notably, the ability to help students develop project management skills received the highest rating in this section (Q12: M = 4.1818). Finally, and central to the research, teachers expressed agreement that the "Smart Clothes Rack" project has the potential to foster leadership capacity in students (Q13: M = 3.9697), affirming the project's significant potential to support the holistic development of learners.

4. Discussion

The research results have painted a valuable overall picture of teachers' perceptions regarding the integration of STEM education and the fostering of leadership capacity. A prominent highlight is the strong support and positive perception of teachers towards STEM education(Bencze et al., 2018; English, 2016). They not only clearly understand its importance but are also confident in their ability to implement STEM projects in their teaching practice. Concurrently, teachers also distinctly recognize the need for leadership capacity development among students and highly value the potential of a specific project like the "Smart Clothes Rack" to develop these important skills(Breiner et al., 2012; Dorph et al., 2018). However, a noteworthy paradox was identified: despite recognizing the need, specific programs or activities for leadership development in schools remain limited and do not meet the demand.

These findings carry several important implications. The high praise for the "Smart Clothes Rack" project's ability to promote teamwork, problem-solving, and project

management skills suggests that well-designed STEM projects are a practical solution to fill the gap in soft skill development(Hà et al., 2023; Hán & Đỗ, 2023). These projects create an experiential learning environment where students not only learn knowledge but also practice leadership roles in a safe context. This aligns perfectly with the project's initial objective to "foster leadership capacity for students through teamwork, problem-solving, and project management". Furthermore, the fact that the mean score for the question on the necessity of fostering leadership (Q7: M = 3.6667) was somewhat lower than other items may indicate a diversity of opinion among teachers, or a certain skepticism about its role and feasibility in the current secondary education curriculum.

These research findings also resonate with the broader context of educational reform in Vietnam. The enthusiasm of teachers for STEM reflects its compatibility with the general policy of the education sector to enhance competency-based teaching methods. However, the lack of leadership development programs also highlights the challenges in implementation, similar to what (Nguyễn et al., 2021)research mentioned regarding the general implementation of STEM. If the widespread implementation of STEM has already faced difficulties, achieving specialized goals such as fostering leadership capacity will certainly require greater effort and investment(Breiner et al., 2012; Phạm et al., 2023).

Finally, it is necessary to frankly acknowledge the limitations of the study. First, the reliability of the survey instrument, with a Cronbach's Alpha of 0.637, is only at an acceptable level. A deeper analysis shows that some items (Q11, Q12) have negative item-total correlations, suggesting that the scale needs to be reviewed, revised, or improved to enhance consistency in future research. Second, the survey sample is small (N=33) and not particularly diverse, with 84.8% of participating teachers having more than 10 years of experience. This may affect the generalizability of the results, as the views of this experienced group of teachers may differ from those of newer teachers.

5. Conclusion and Recommendations

5.1. Conclusion

This study has surveyed and analyzed teachers' perceptions of fostering student leadership capacity through a specific STEM project, the "Smart Clothes Rack". The results have clearly affirmed that teachers have a very positive perception and a clear understanding of the importance of STEM education for the holistic development of students. Although STEM projects are being implemented in schools, the study also reveals a significant gap between the perceived necessity of fostering leadership capacity and the lack of specific support programs in practice.

In this context, the "Smart Clothes Rack" project emerges as a typical model, highly valued by teachers for its potential and effectiveness. The project is believed to have the ability to develop crucial foundational skills such as teamwork, problem-solving, project management, and thereby directly foster leadership capacity in learners. In summary, the study concludes that integrating well-designed STEM projects with clear skill-development

objectives is a feasible and effective strategy to cultivate necessary 21st-century competencies for high school students.

5.2. Recommendations

Based on the results and conclusions drawn, this study proposes several recommendations for educators and schools. Specifically, the adoption and replication of STEM project models with dual objectives—both reinforcing subject knowledge and fostering soft skills such as leadership capacity—should be encouraged and expanded. Schools should consider establishing systematic programs, extracurricular activities, or integrating leadership development content to meet the practical needs that teachers have identified. Concurrently, organizing training sessions and professional development for teachers on methods for designing, implementing, and assessing competency-based outcomes in STEM projects, especially for skills that are difficult to measure such as leadership, is essential.

Regarding directions for future research, this study suggests several potential avenues. First, research should be conducted to improve and standardize the survey instrument ; revising the problematic items (such as Q11 and Q12) is necessary to enhance the scale's reliability. Furthermore, future studies should be conducted on a larger and more diverse sample in terms of characteristics (work experience, region) to increase the generalizability of the findings. More importantly, researchers should implement experimental or quasi-experimental studies to measure the actual impact of STEM projects on students' leadership capacity, rather than relying solely on teacher perceptions. This would provide more robust evidence of the method's effectiveness.

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