e-ISSN 3050-9599
p-ISSN 2795-3264

GPH INTERNATIONAL JOURNAL OF EDUCATIONAL RESEARCH
OPEN ACCESS www.gphjournal.org

10.5281/zenodo.17076071 | Vol. 08 Issue 08 August - 2025 | Manuscript ID: #02073

The Impact of Using Phyphox Software in Physics Teaching on the Development of Students' Leadership Competency

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Abstract

In the context of Vietnam's 2018 General Education Program, which emphasizes the comprehensive development of competencies and qualities for students, this study addresses the challenges of traditional Physics teaching methods that are heavy on theory and provide few opportunities for soft skills development. The objective of this paper is to evaluate the effectiveness of integrating the Phyphox software into the teaching of the “Uniformly Accelerated Motion” section of 10th-grade Physics to develop students' leadership competency. The research was conducted using a pedagogical experiment method with a mixed qualitative and quantitative approach. A lesson plan for a practical experiment to measure free-fall acceleration was designed and implemented in class 10A13 at Dong Hy High School, Thai Nguyen. The leadership competency of a core group of 4 students was analyzed in-depth through observation, interviews, and evaluation forms based on a 7-component competency framework. The qualitative results showed a vibrant classroom atmosphere, with students actively and enthusiastically participating in the experiments. Quantitatively, the results indicated significant development in components of leadership competency such as strategic thinking, problem-solving, and ethical responsibility. The leadership competency scores of the core students were high and showed a positive correlation with their academic performance in Physics. The study affirms that using Phyphox is a feasible and effective solution, not only helping students approach Physics knowledge visually but also creating a collaborative learning environment, thereby fostering and developing leadership competency, meeting the goals of modern education.

Keywords:

Phyphox, Leadership Competency, Physics Teaching, Pedagogical Experiment, 2018 General Education Program.

***How to cite*:** Tien Khoa, C., & Quang Linh, N. (2025). The Impact of Using Phyphox Software in Physics Teaching on the Development of Students’ Leadership Competency. *GPH-International Journal of Educational Research*, 8(8), 19-30. https://doi.org/10.5281/zenodo.17076071

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1. Introduction

1.1. Context and Rationale

The educational landscape in Vietnam is undergoing a significant transformation with the implementation of the 2018 General Education Program (GEP). This program sets a core requirement for innovating teaching methods, shifting from the goal of knowledge transmission to the comprehensive development of competencies and qualities in learners (Thông Tư 32/2018/TT-BGDĐT, n.d., p. 32). Among these, soft skills such as leadership, teamwork, and problem-solving are particularly emphasized to equip students with a solid foundation to become dynamic and autonomous global citizens.

However, the current state of Physics teaching in many high schools still faces challenges. Teaching methods largely remain a one-way transmission, focusing on theory and formulas, while practical and experiential activities are limited. This inadvertently reduces students' interest and creates few opportunities for them to promote their proactivity, creativity, and practice necessary soft skills.

In this context, the remarkable development of digital technology and the popularity of smart mobile devices in students' lives have opened up a promising new direction. Instead of being just tools for entertainment or communication, smartphones can be integrated into the teaching process, becoming a powerful and effective personalized learning tool that vividly connects theory with practice.

1.2. Problem, Objectives, and Research Hypothesis

One of the outstanding applications following this trend is the Phyphox software, a free application capable of utilizing the built-in sensors on a smartphone to turn it into a compact and versatile Physics experiment toolkit. From measuring acceleration and angular velocity to analyzing sound frequencies, Phyphox allows students to conduct experiments visually right in the classroom or at home.

This raises an important research question: Can the design and organization of Physics teaching activities supported by the Phyphox software positively impact the development of students' leadership competency? Is this active, collaborative, and experiment-based learning environment a catalyst for forming and nurturing the qualities of a future leader?

Therefore, this study is conducted with the specific objective: To research the design and organization of teaching using the Phyphox software in the “Uniformly Accelerated Motion” section of the 10th-grade Physics curriculum to develop students' leadership competency.

To achieve the above objective, the study proposes the following scientific hypothesis: If teaching is designed and organized using the Phyphox software in a reasonable and scientific manner in the "Uniformly Accelerated Motion" section of 10th-grade Physics, it will develop leadership competency in students.

2. Literature Review

2.1. Technology Integration and Experimentation in Physics Teaching

The role of the experimental method in science has long been affirmed, originating from pioneering scientists like Galileo Galilei, who laid the foundation for using experiments to verify scientific hypotheses. In modern education, active teaching methods such as "La main à la pâte" (LAMAP) continue to emphasize the importance of letting students discover knowledge themselves through observation and experimentation (L. H. Bùi, 2023). These methods help students not only understand knowledge deeply but also develop scientific thinking and problem-solving skills.

In Vietnam, many research works have focused on innovating Physics teaching methods by increasing the use of experiments. These studies include diverse forms, from virtual experiments and computer simulations to encouraging students to create simple experiment kits themselves (V. H. Bùi et al., 2021; Hán & Đỗ, 2023).The rise of the Fourth Industrial Revolution has opened a new direction, which is the integration of personal technology devices, especially smartphones, into teaching (Alvarez & Agra, 2006). Many international studies have demonstrated the effectiveness of using applications like Phyphox to turn smartphones into mobile laboratories, helping students perform physical measurements with high accuracy in an easy and engaging way (Alfrey et al., 2017; Attard & Armour, 2006).This approach is particularly suitable for modern teaching models such as project-based learning (Anazifa & Djukri, 2017; Nguyễn Thị Diễm & Lê Danh, 2021),where students play a central role in the process of knowledge construction.

2.2. Leadership Competency and Its Development in High School Students

The 2018 GEP defines "competency" as a personal attribute formed and developed through innate qualities and the process of learning and training, allowing a person to mobilize a combination of knowledge, skills, and other personal attributes to successfully perform a certain type of activity, achieving desired results under specific conditions (Ministry of Education and Training, 2018).

On that basis, "leadership competency" can be understood as the ability of an individual to influence, motivate, and guide a group of people to cooperate to achieve a common goal (Eustachio et al., 2024; Hargreaves & Fink, 2012). For students, this competency is not limited to official class officer roles but is also demonstrated through the ability to proactively propose ideas, coordinate group activities, and listen to and respect others' opinions. Many studies have shown that leadership competency is not entirely innate but can be trained and developed through factors such as personal characteristics, family environment, and especially learning experiences at school. A learning environment that encourages autonomy, empowerment, and requires collaboration will be the ideal condition to nurture this competency (Acun Çelik et al., 2024).

2.3. Theoretical Framework of Leadership Competency

To have a solid basis for measurement and evaluation, this study uses the Leadership Competency Assessment Framework developed and proposed by Nguyen Quang Linh and Cao Tien Khoa (2024), which is designed to be suitable for the context of Vietnamese high school students (Nguyen & Cao, 2024).This theoretical framework is composed of 7 component competencies, including:

(1) **Strategic Thinking (TT1):** The ability to define a vision, set clear goals, and plan actions for the group.
(2) **Effective Communication (TT2):** Skills in listening, presenting ideas persuasively, and conveying information clearly.
(3) **Management and Delegation (TT3):** The ability to organize, assign tasks reasonably based on members' strengths, and monitor work progress.
(4) **Problem-Solving and Decision-Making (TT4):** The competency to analyze situations, identify the core of a problem, and make optimal choices.
(5) **Team Motivation (TT5):** The ability to encourage, inspire, and build a positive and collaborative team working environment.
(6) **Flexibility and Adaptability (TT6):** The ability to adjust plans and methods when facing unexpected changes or challenges.
(7) **Ethics and Social Responsibility (TT7):** A sense of responsibility for common work, acting fairly, with integrity, and as a role model.

3. Research Methodology

To test the proposed scientific hypothesis, the study was conducted using the pedagogical experiment (PE) method. A mixed-methods approach, combining qualitative and quantitative assessment, was chosen to provide a comprehensive and in-depth perspective. The qualitative method was used to record the context, developments, and attitudes of students during the lesson, while the quantitative method helped to objectively measure the development level of leadership competency through specific data.

The study was implemented at Dong Hy High School, Thai Nguyen province, with 50 students from class 10A13 participating in the 2024-2025 academic year. To conduct a thorough assessment, the study focused on observing and analyzing 4 students who served as group leaders for the 4 learning groups in the class. The selection of these students as the focal subjects was because they held key roles in coordinating, organizing, and leading group activities, making them ideal individuals to observe and evaluate the manifestation and development of leadership competency.

The research process was carried out rigorously through three successive stages. The preparation stage included developing a detailed lesson plan for Lesson 11: “Practice: Measuring Free-Fall Acceleration,” which integrated the use of the Phyphox software as a primary experimental tool, while also designing and finalizing the leadership competency assessment toolkit. Next, the implementation stage involved organizing the experimental teaching session according to the prepared plan. The entire lesson was structured around five main activities: proposing experimental methods, reporting group discussions, conducting experiments with Phyphox, reporting the obtained results, and finally, summarizing and evaluating. The final stage was data collection and analysis, where the prepared tools were used to record the entire process, followed by scoring and analyzing the results to draw conclusions.

To collect data from multiple perspectives, a diverse set of tools was used. For qualitative data, a classroom observation protocol was used to record prominent behaviors, attitudes, and interactions of students. Photos and videos were also utilized to authentically capture the process of students working in groups, discussing, and conducting experiments. After the session, a feedback form was distributed to collect their responses and feelings. For quantitative data, the main tool was the leadership competency evaluation form, built upon the 7-component theoretical framework. This form included 21 specific behavioral indicators, each assessed on a 3-level scale (Not Met, Met, Good). Additionally, the average Physics scores of the students were collected as reference data for comparison.

4. Results

4.1. Qualitative Findings

Through direct observation, video recording, and note-taking during the experimental lesson on "Practice: Measuring Free-Fall Acceleration," a very positive, vibrant, and serious learning atmosphere was observed. Students showed clear enthusiasm when approaching Physics knowledge through a new, highly interactive method.

During the activity of proposing and discussing methods (Activities 1 & 2), the groups worked very seriously. They actively discussed and debated to come up with feasible experimental plans. The classroom atmosphere became lively when representatives from each group presented their ideas. Notably, students not only presented passively but also actively asked questions, debated, and added opinions for other groups. For example, one student suggested using a "non-stretchable string" for the simple pendulum experiment, while another group proposed an additional method using an "inclined plane." This shows that students had begun to engage in a genuine scientific thinking process, from brainstorming to validating the rationality of their ideas.

When moving to the practical experiment activity (Activity 3), the students' proactivity was most evident. The groups self-assigned tasks: one person to drop the object, one to time it, one to record data, and one to operate the Phyphox software. The use of Phyphox generated great excitement; the students were thrilled to turn their familiar phones into precise measurement tools. Although some were initially awkward and clumsy with the software, these difficulties were quickly overcome with group collaboration. The teacher at this point acted as an observer and supporter when needed, rather than a step-by-step instructor.

In the activity of reporting and discussing results (Activity 4), the classroom atmosphere continued to be lively with debates over the data. The groups compared their results with other groups and with the theoretical value. They boldly pointed out possible sources of error, such as “the way the stopwatch was pressed” or “inaccurate measurement of the string length.” Particularly, when comparing the results between the manual measurement method and the Phyphox method, a student remarked: “the Phyphox software will give more accurate results because... it measures with sound, so it will have higher precision.” This is evidence that students did not just perform the experiment mechanically but also analyzed, compared, and evaluated the reliability of the methods.

After the lesson, the feedback received from students was very positive. One student shared: “I found this to be a very fun and meaningful lesson... it helped us apply the knowledge we learned to practice.” Another student said: “The Phyphox software helps me understand and remember the formulas more easily... rather than just learning theory from the textbook.” Overall, this teaching method succeeded in sparking curiosity, interest, and a spirit of proactivity among students, creating a learning environment where they were truly at the center of the knowledge construction process.

4.2. Quantitative Analysis of Pedagogical Experiment Results

To quantify the effectiveness of the experimental teaching method, we assessed the leadership competency of the 4 core students based on the 7-component competency framework. The assessment was conducted using a scoring sheet with 21 specific behavioral indicators, each scored on a 3-level scale. The maximum total score was 63, which was then converted to a 10-point scale for ease of comparison and analysis.

The summarized results of the leadership competency of the 4 group leaders are detailed in Table 1 and visualized in Figure 1.

Table 1. Results of “Measuring” the Leadership Competency of 4 Students

Student ID		N1.10A13 - TN			N2.10A13 - TN			N3.10A13 - TN			N4.10A13 - TN		
Competency Component	Level	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
TT1	TD1			√			√			√			√
	TD2			√			√			√		√	
	TD3		√				√		√				√
TT2	GT1			√			√		√				√
	GT2		√			√			√				√
	GT3			√		√				√			√
TT3	QL1		√				√		√			√	
	QL2		√			√				√		√	
	QL3			√		√		√					√
TT4	VD1			√			√			√	√		

	VD2			√		√				√			√
	VD3			√		√			√				√
TT5	DL1			√			√		√				√
	DL2		√				√			√			√
	DL3			√			√	√			√		
TT6	LH1		√			√				√			√
	LH2		√				√	√					√
	LH3		√		√					√			√
TT7	DD1			√			√			√		√	
	DD3			√			√		√				√
Total Score		55			51			47			54		
Converted Score (10-point scale)		9,5			8,5			8,0			9,0		

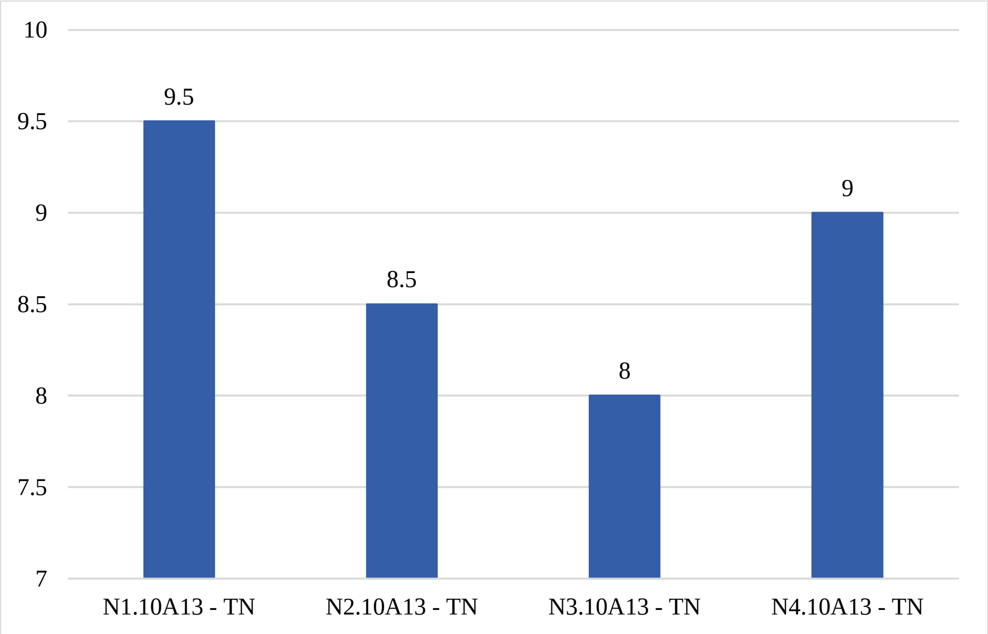

Figure 1. Bar Chart of Students' Leadership Competency Assessment Scores

Overall, the quantitative results show a very positive picture. All 4 assessed students achieved high leadership competency scores, ranging from 8.0 to 9.5. Specifically, student N1.10A13 - TN achieved the highest score (9.5), followed by N4.10A13 - TN (9.0) and N2.10A13 - TN (8.5). Student N3.10A13 - TN, despite having the lowest score in the group, still reached a level of 8.0. These numbers provide objective evidence, reinforcing the qualitative observations that the Phyphox-based learning environment created favorable conditions for students to exhibit and develop their leadership roles.

For a deeper insight, we analyzed the scores of each student across the 7 competency components (Figure 2).

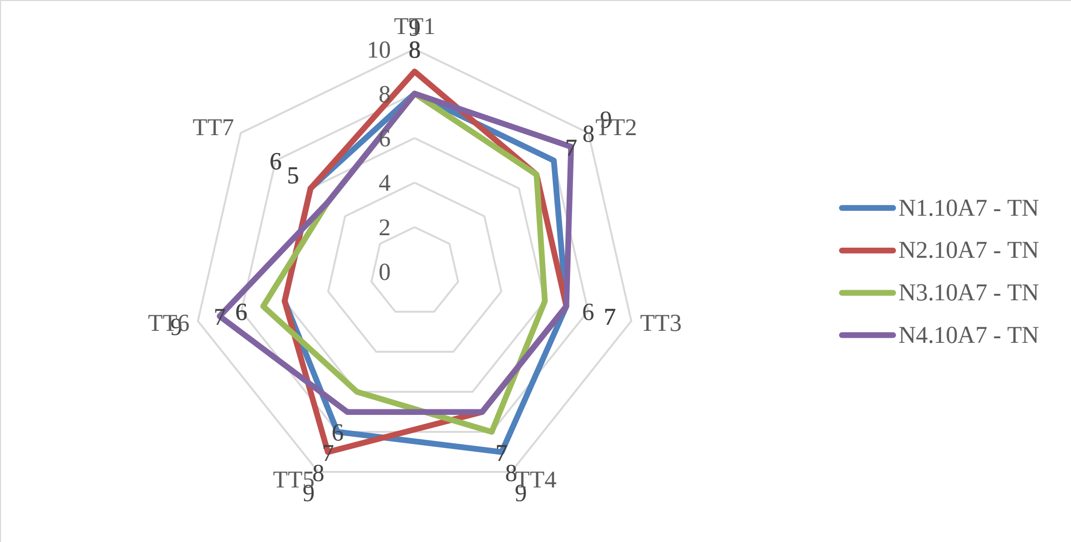

Figure 2. Bar Chart of Leadership Competency Scores of 4 Students by Component

The analysis of the chart shows relatively even development in foundational competencies such as Strategic Thinking (TT1) and Ethics and Social Responsibility (TT7) across all 4 students. This indicates that they all possess the ability to define common goals and act responsibly during group work.

However, the chart also reveals specific strengths and areas for improvement for each individual:

- In Problem-Solving and Decision-Making (TT4), student N1 showed outstanding performance with a perfect score, demonstrating an effective ability to analyze situations and make optimal choices.
- Effective Communication (TT2) was a highlight for student N4, reflecting skills in presentation, persuasion, and clear information delivery.
- Meanwhile, student N2 excelled in Flexibility and Adaptability (TT6), showing agility in adjusting plans in the face of changes.
- A noteworthy point is that Management and Delegation (TT3) was an area where all 4 students needed further improvement, suggesting that organizing and assigning tasks based on individual strengths is a complex skill that requires more time and practice.

Finally, to investigate the relationship between leadership competency and academic performance, we compared the competency assessment scores with the students' average Physics scores for the first semester (Table 2 and Figure 3).

Table 2. Physics Scores of the 4 Students

No	Student ID	Average Physics Score (Semester I)	Leadership Competency Score				GPA	Competency Assessment Score
1	N1.10A13 - TN	Regular Grades	7	8	7	8	8,2	9,5
		Mid-term Grades	9					
		Final Grades	8,5					
2	N2.10A13 - TN	Regular Grades	7	10	8	10	7,7	8,5
		Mid-term Grades	7,5					
		Final Grades	6,5					
3	N3.10A13 - TN	Regular Grades	9	7	9	9,5	8,3	8,0
		Mid-term Grades	8,0					
		Final Grades	8,0					
4	N4.10A13 - TN	Regular Grades	7	8	9	8,5	7,9	9,0
		Mid-term Grades	8,3					
		Final Grades	7,3					

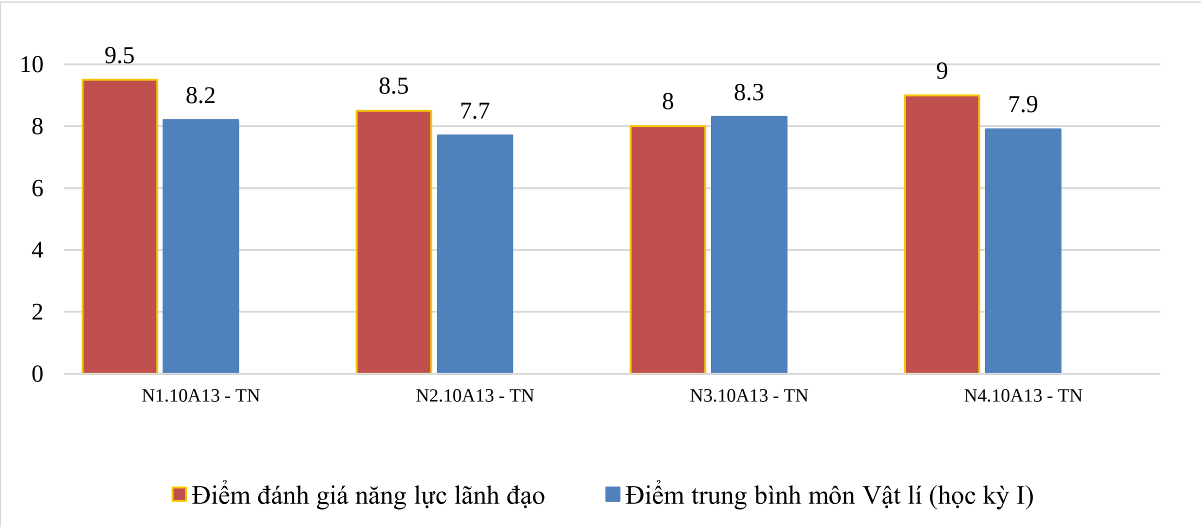

Figure 3. Comparative Chart of Leadership Competency Score and Average Physics Score (Semester I)

The results show a positive but not entirely uniform correlation. In 3 out of 4 cases (N1, N2, N4), the leadership competency score was higher than the average academic score. This implies that students who demonstrated good leadership roles in the practical activity also tended to achieve good academic results. However, the case of student N3 (average academic score higher than leadership competency score) shows that excellent academic achievement does not always go hand-in-hand with outstanding leadership skills in every activity. The not-so-large gap between these two sets of scores suggests that fostering a positive learning environment not only helps develop soft skills but also has the potential to favorably impact academic performance.

Thus, the quantitative data have strongly confirmed that integrating the Phyphox software into practical Physics teaching has had a clear impact on the development of students' leadership competency. These objective measurement results are fully consistent with the qualitative findings, affirming the effectiveness of the research hypothesis.

5. Discussion

The research findings provide convincing evidence that affirms the validity of the proposed scientific hypothesis. The integration of the Phyphox software into practical teaching not only makes Physics lessons more engaging but also truly creates an ideal environment for students' leadership competency to be formed and developed.

A deeper analysis reveals that the success of this method lies not in the technology itself, but in how the technology is used to restructure the learning activity. Instead of being passive recipients, students are placed in the position of real scientists: proposing methods, collaborating to solve problems, analyzing data, and defending their results. This process requires them to apply a range of core leadership behaviors: from setting common goals (Strategic Thinking), assigning tasks (Management and Delegation), to persuading members (Effective Communication) and making final choices (Problem-Solving). The quantitative results with high scores have objectified these positive manifestations. The positive correlation between leadership competency scores and academic results is also a valuable finding, suggesting that soft skills training can support the mastery of subject matter knowledge.

In practical terms, this study provides a feasible and effective solution for Physics teachers to innovate their teaching methods, meeting the requirement of comprehensive competency development for students under the 2018 General Education Program. In theoretical terms, the study contributes to clarifying the scientific basis for developing leadership competency through experiential learning activities in the context of a natural science subject, a field often considered dry and theory-heavy.

However, we recognize that the study still has certain limitations. The small sample size, conducted in only one classroom and limited to one practical lesson, may reduce the generalizability of the results. Besides, not all students showed uniform progress; some were still confused when facing complex problems, indicating the need for more personalized skill support and coaching.

From these limitations, future research can be expanded in several directions. Implementing the method on a larger scale, over a full semester or academic year, and across various topics in Physics will allow for more robust conclusions. Concurrently, more in-depth comparative studies between student groups with different individual characteristics will help to better identify the impact of the method on each specific type of student.

6. Conclusion

The study has convincingly demonstrated that designing and organizing teaching with the use of the Phyphox software in the "Uniformly Accelerated Motion" section of the 10th-grade Physics program is an effective solution for developing students' leadership competency. The initially proposed scientific hypothesis has been strongly affirmed through both qualitative and quantitative results.

This teaching method has succeeded in transforming the classroom atmosphere from a one-way knowledge transmission model to a collaborative, interactive, and active learning environment. Through practical experimental activities, students not only approach Physics knowledge more visually and enthusiastically but are also given the opportunity to practice essential soft skills. The measurement results show clear development in the components of leadership competency such as strategic thinking, problem-solving, and a sense of responsibility.

This research affirms that the rational integration of technology not only increases the effectiveness of teaching subject matter knowledge but is also a powerful tool for nurturing the qualities and competencies necessary for 21st-century citizens. The results of this study open up a new pedagogical approach, consistent with the goals of the 2018 General Education Program, contributing to equipping students with a solid foundation to become autonomous and dynamic individuals in the future.

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