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DEVELOPING STUDENTS' SELF-LEARNING COMPETENCY THROUGH THE FLIPPED CLASSROOM MODEL IN TEACHING CHEMISTRY FOR GRADE 10

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Abstract. This study examines the effectiveness of the flipped classroom model in enhancing self-learning competency among Grade 10 chemistry students. The research was conducted with students from two Vietnamese high schools using a mixed-methods approach to evaluate the impact of the flipped classroom on topics such as "Chemical Energy" and "Reaction Rate". The experimental group engaged in flipped classroom activities, which included video lectures and collaborative in-class exercises, while the control group received traditional instruction. Data were collected through observations, surveys, and pre- and post-tests, and analyzed using descriptive and inferential statistics. Results indicated that the flipped classroom model significantly improved students' self-learning competency and engagement. The experimental group demonstrated higher test scores, and qualitative feedback highlighted increased initiative and collaboration among students.

Keywords: high school, self-learning competency, flipped classroom, grade 10, chemical energy, reaction rate.

1. Introduction

In recent years, the demand for educational innovation has intensified due to rapid technological advancements and the evolving requirements of a knowledge-based economy. This shift has redefined the role of education, necessitating a transformation in the teaching-learning process to equip students with lifelong learning skills [1], [2]. Among the various skills deemed essential, self-learning, or the ability to independently acquire, process, and apply knowledge, has emerged as a core competency [3]. However, traditional educational approaches, especially in scientific subjects such as chemistry, often emphasize rote memorization over critical thinking and autonomous learning. This emphasis may hinder students' capacity to learn independently, leaving them ill-prepared to thrive in an environment where self-directed learning is crucial [4], [5]. Consequently, there is a growing need for pedagogical models that foster self-learning and adaptability among students [6]. One such model, which has gained popularity in recent years, is the flipped classroom model.

The flipped classroom model inverts the traditional approach to teaching by assigning instructional materials, such as lectures and readings, as homework while utilizing classroom time for interactive, hands-on activities [7], [8]. This approach allows students to engage with foundational content at their own pace outside of class, freeing up classroom sessions for deeper exploration, collaboration, and application of knowledge [9]. Research suggests that the flipped classroom model has the potential to enhance students' engagement, comprehension, and problem-solving skills by shifting the focus from passive absorption of information to active involvement in the learning process [10]. By integrating self-paced learning within-class collaborative activities, the flipped classroom provides an ideal environment to develop self-learning abilities in students, as it encourages them to take responsibility for their own learning [11].

Chemistry, a subject characterized by complex concepts and intricate problem-solving, presents unique challenges for educators aiming to develop students' self-learning abilities. Traditional lecture-based methods in chemistry often fail to engage students or address the diverse learning needs of a typical classroom [12]. Moreover, the abstract nature of chemical concepts can lead to difficulties in comprehension, as students may struggle to relate theoretical principles to real-world applications [13]. In this context, the flipped classroom model can serve as an effective alternative by allowing students to gain initial exposure to content through video lectures, readings, or other resources at their own pace. This independent exploration is further reinforced through classroom activities that promote critical thinking, collaborative problem-solving, and application of knowledge in practical scenarios [14]. Thus, the flipped classroom model not only aligns with the objectives of modern educational reforms but also has the potential to address specific challenges associated with teaching chemistry [15].

2. Content

2.1. Research methods

**** Research design***

This study focuses on developing self-learning competencies for Grade 10 students through the use of the flipped classroom model in teaching the "Chemical Energy and Reaction Rate" topics. The primary research objectives include assessing the flipped classroom's impact on students' self-learning abilities and understanding of chemistry concepts. To achieve this, data were collected through classroom observations, surveys, and pre-and post-tests. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative data were examined through thematic analysis.

**** Participants***

The study was conducted with Grade 10 students from two high schools: Nguyen Viet Xuan High School in Vinh Tuong, Vinh Phuc, and Nam Tien Hai High School in Tien Hai District, Thai Binh. The participant selection included both an experimental and a control class at each school, implementing instructional plans designed around the topics of "Chemical Energy" and "Reaction Rate" in Chemistry. Students were assessed on their self-learning abilities using evaluation forms created for both teachers and students to gauge progress. This selection allowed for a diverse representation of learning environments to evaluate the effectiveness of the flipped classroom model in enhancing self-learning competency.

**** Data collection instruments and data analysis***

Data were collected through various assessment tools, including evaluation forms, self-evaluation forms, and tests conducted before and after instructional sessions. Specifically, students completed two 15-minute tests after each teaching experiment and a 45-minute test after completing Chapters 5 and 6. Additionally, teachers filled out evaluation forms based on predetermined self-learning competency criteria, and students conducted self-assessments.

The collected data were processed using mathematical statistics. Scores from teaching experiment classes were analyzed to include frequency and cumulative frequency distribution tables, summary classification tables, and cumulative frequency graphs. An independent T-test determined statistical significance (p-value) to compare average scores between experimental and control groups, with $p \leq 0.05$ indicating meaningful differences. Effect size (ES) was calculated using Cohen's criteria to assess the impact, where $ES \geq 0.5$ was considered significant for broader implementation.

2.2. Flipped classroom model

The flipped classroom model is an innovative teaching approach. This model has fully exploited the advantages of information technology and contributed to solving the limitations of the traditional teaching model by "reversing" the teaching process compared to the traditional teaching model. The "reversal" here is understood as a change in pedagogical intentions and strategies, reflected in the implementation of teaching content, objectives, and activities that differ from the traditional way of teachers and learners [11], [12].

In the flipped classroom model, the activities of "Learning in class, doing homework" (in the traditional classroom model) are transformed into self-study activities at home through video lectures, online learning, studying lessons via the Internet, and when coming to class, learners will do homework, exchange and share the content of lessons, solve problems and situations posed by teachers [13]. Learners will have to work with the lecture in advance through reading documents, summarizing documents, listening to lectures through supporting means such as clips, slideshows, as well as searching and exploiting materials to serve the study of the lesson. The teacher's lecture is sent to the student in advance and becomes a homework assignment that the learner must prepare before going to class. The entire time in class will be spent on teacher-oriented activities, listening to learners' reports, exchanging and sharing their preparation before the teacher consolidates and officially finalizes the content of the lesson [14], [15].

2.3. Self-learning competency

Develop a set of tools to assess self-learning competency. Assessment of secondary education is an important part of the learning process, helping students assess their ability to orient learning and develop secondary education. Based on the research of the authors Nguyen Hoang Trang [9] on student education, we researched and identified some quality papers presented in Table 1.

Table 1. Describing the criteria and levels of assessment of self-study competency development according to the reverse classroom model

Criteria	Level 1	Level 2	Level 3
1. Determining the objectives and contents that need to be addressed.	*The* objectives and content of self-study have not been determined.	Self-study objectives and content have been identified but *are incomplete.*	Items' objectives have been identified; the self-study content *is accurate and complete.*
2. Determination of self-study methods and means.	*The* method *and means of self-study* have not been determined.	Self-study methods and means have been identified, but are *not suitable* for self-study content.	The method and means have been determined *in accordance* with the content of the self-study.
3. Determining the self-study time and expected results.	Determining the self-study time *is not reasonable; the results are not expected.*	The reasonable time for self-study has been determined, *but the* results are not expected to be achieved.	The reasonable time for self-study has been determined, *and* the results are expected to be achieved.

Criteria	Level 1	Level 2	Level 3
4. Searching and collecting self-study information sources.	Sources of information *that are inaccurate and inconsistent* with the self-study content have been searched for and collected.	*Accurate sources of information that are suitable* for self-study *content, but incomplete, have been searched for and collected.*	Search and collect *accurate, complete sources of information suitable* for self-study content.
5. Analyzing and processing the information sought.	Inaccurate information has been analyzed and processed.	Accurate *but incomplete information has been a*nalyzed and processed.	Accurate *and complete information has been a*nalyzed and processed.
6. Applying knowledge and skills to solve learning situations/tasks.	Knowledge and skills have been applied to solve learning situations/tasks, but they *are not accurate.*	Knowledge and skills have been applied to solve learning situations/tasks *correctly, but they are incomplete.*	Knowledge and skills have been applied to solve learning situations/ tasks *accurately and completely.*
7. Evaluation of self-study results according to the task evaluation scale.	Self-study results are evaluated according to the task evaluation scale, *which is not accurate.*	Self-study results are evaluated according to the task evaluation scale, which *is accurate but incomplete.*	Self-study results are evaluated according to an *accurate and complete task evaluation scale.*
8. Overcoming mistakes, limitations, and self-adjusting your learning style.	*They have not realized* their mistakes, limitations, and *cannot adjust their own* learning style.	*They have recognized* their own mistakes and limitations, but *cannot adjust their learning* methods appropriately.	*They have recognized* their own mistakes and limitations and *adjusted their* learning style accordingly.

2.4. Applying the flipped classroom model to develop students' self-learning competency in teaching chemistry 10

The process of organizing teaching according to the flipped classroom model to develop students' self-learning competency is carried out through 3 stages as follows [16]-[18]:

Phase I: Self-study at home

The process of self-study at home for students goes through 5 steps (Figure 1), including: Introduction of lessons; defining goals; self-study planning; learning according to e-learning lectures; self-inspection and evaluation.

Step 1: Introducing the lesson

Teachers: introduce lessons and learning materials in the virtual classroom on the OLm website.

Students: learn about lessons and learning materials to understand the purpose, audience, requirements of the course, learning methods, and learning plans.

Step 2: Determining lesson objectives

Teachers: orient students by assigning tasks to students.

Students: read the introduction to self-study, self-study forms, watch lecture videos, self-study guides, etc., thereby clearly understanding the purpose, objectives, requirements, and learning process.

Step 3: Making a self-study plan

Teachers: instruct students to exploit the learning material warehouse.

From the lesson objectives, students design their self-study plan: implementation time, how to collect documents, analyze and process information and products; record that plan in the self-study notebook; and draw their comments and experiences after each self-study lesson.

These activities help students develop self-study capacity with the component capacity of building a self-study plan.

Step 4: Following the e-lecture

Teachers: be available to support students as they perform operations in the virtual classroom.

Students: study on their own according to the self-study instruction sheet, through E-learning lectures (designed by the teacher himself) or lecture videos collected by the teacher. This activity helps students develop self-study capacity with the component capacity of implementing a self-study plan.

Step 5: Self-test, evaluating, adjusting, and learning from experience

Teachers: track progress, mark students' assignments, and assess students' self-learning competency.

Teachers can statistically analyze the results of online tests, and each question will have a portion of students answering correctly. From there, teachers will determine which self-learning content students understand, and which self-learning content students are still unclear about, and dreaming about. At the same time, teachers will take measures to support students with that knowledge content in class.

Assessing students' self-learning competency is based on self-study notebooks, self-study test results, and self-study worksheets.

Students: do a self-check of the self-study process in the virtual classroom, draw comments and experiences for themselves. Students rely on the results of a 15-minute test related to the content of new knowledge they have just learned on their own, thereby detecting errors in the self-learning process. This activity helps students develop self-learning competency with the component competency of evaluating results and adjusting the self-learning process.

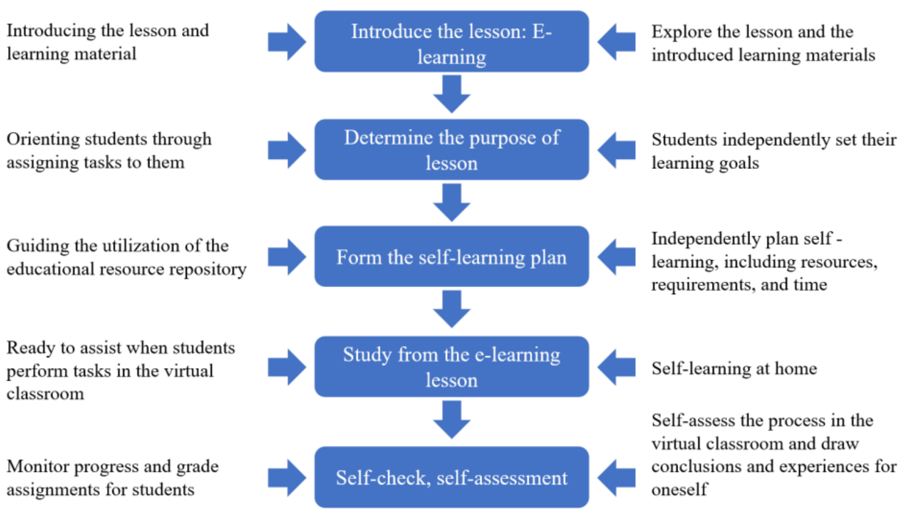

Figure 1. Steps to self-study at home

Phase II: Classroom learning

Activity 1: Warm-up.

Activity 2: Systematizing the knowledge of the whole lesson.

Step 1: Comment on the student's self-learning results.

Step 2: Present the learning results (if any).

Step 3: Organize students to discuss the problems that exist in the self-study section.

Step 4: Answer questions that exist after the exchange and discussion among students.

Step 5: Expand and deepen the key and difficult knowledge of the lesson.

Step 6: Close the whole lesson with a mind map.

Activity 3: Practice.

Activity 4: Apply.

Phase III: Evaluation

Teachers assess students' self-learning through:

Assessment through self-study results at home (online tests, self-study notebooks)

Evaluation through the presentation of the class groups.

Assessment through a 15-minute test after each lesson and a test 45 minutes after the end of the chapter on alkaline metals, alkaline earth metals, and aluminum.

2.5. Results

2.5.1. Area, subjects, and content of the pedagogical experiment

We conducted the pedagogical experiment at high schools with 10th-grade students from two institutions: Nguyen Viet Xuan High School in Vinh Tuong, Vinh Phuc, and Nam Tien Hai High School in Tien Hai District, Thai Binh Province. The objective was to evaluate the feasibility and effectiveness of using the flipped classroom model to foster students' self-learning competency while studying the 10th-grade topic "Chemical energy and reaction rate." The research team selected 40 students from experimental class 10A1 and 42 students from the control class 10A2 at Nguyen Viet Xuan High School in Vinh Tuong, Vinh Phuc, as well as 42 students from experimental class 10A and 44 students from control class 10B at Nam Tien Hai High School in Tien Hai District, Thai Binh Province. These students, with similar academic levels, were chosen as subjects for the experiment. The experiment used predefined criteria to collect results and was conducted through two lessons:

Lesson 15: *The meaning and calculation of enthalpy change – Chemical reactions.*

Lesson 19: *Reaction rate.*

At the same time, we assessed the development of students' self-learning competency based on average scores from evaluation sheets. These scores were provided by teachers and students themselves according to criteria for assessing self-learning competency.

2.5.2. Results of the pedagogical experiment

Qualitative Results: After applying the flipped classroom model in teaching chapters 5 and 6 of 10th-grade Chemistry, experimental class students provided feedback on their experience. The results indicated a significant improvement in students' proactivity, self-learning, and creativity. Prior to the intervention, most students were passive, taking notes on what teachers presented in class, with only a few high-performing students displaying clear signs of self-learning competency. These signs were largely acquired through accumulated experience in self-study. After the intervention, with guided practice and skill training, most students showed very positive outcomes.

Thus, the flipped classroom model effectively supports developing students' self-learning competency.

Quantitative Results: The 45-minute test scores of the experimental group (EG) and control group (CG)are presented in Table 2.

Table 2. 45-minute test results

School	Object	The number of students	Students have scored Xi											GPA
			0	1	2	3	4	5	6	7	8	9	10	
Nguyen Viet Xuan	EG1	40	0	0	0	0	0	0	3	6	6	13	12	8.04
	CG1	42	0	0	0	0	0	0	6	4	8	9	4	7.82
Nam Tien Hai	EG2	42	0	0	0	0	0	1	8	10	14	6	3	7.54
	CG2	44	0	0	0	0	0	5	4	13	13	4	5	7.5
	∑EG	82	0	0	0	0	0	1	11	16	20	19	15	7.79
	∑CG	86	0	0	0	0	0	5	10	17	21	13	9	7.66

The data in Table 2 presents the 45-minute test scores of students from two schools, Nguyen Viet Xuan and Nam Tien Hai, categorized under different groups (EG1, CG1, EG2, CG2). The table shows the distribution of student scores ranging from 0 to 10 for each group. The experimental groups (EG1 and EG2) and control groups (CG1 and CG2) show varying performance, with a higher frequency of scores between 7 and 9. The average GPA across groups (ΣEG and ΣCG) is approximately 7.79 and 7.66, respectively, indicating a slight performance advantage in the experimental groups. This data could suggest a difference in educational intervention effects between experimental and control groups. It shows that the percentage of students who get high scores in the first class is higher than that of the EG class.

Table 3. 45-minute test score aggregate result classification

Weakness (0-4 grade)		Average (5-6 grade)		Fairly (7-8 grade)		Good (9-10 grade)	
EG	CG	EG	CG	EG	CG	EG	CG
0	0	12	15	36	38	34	22

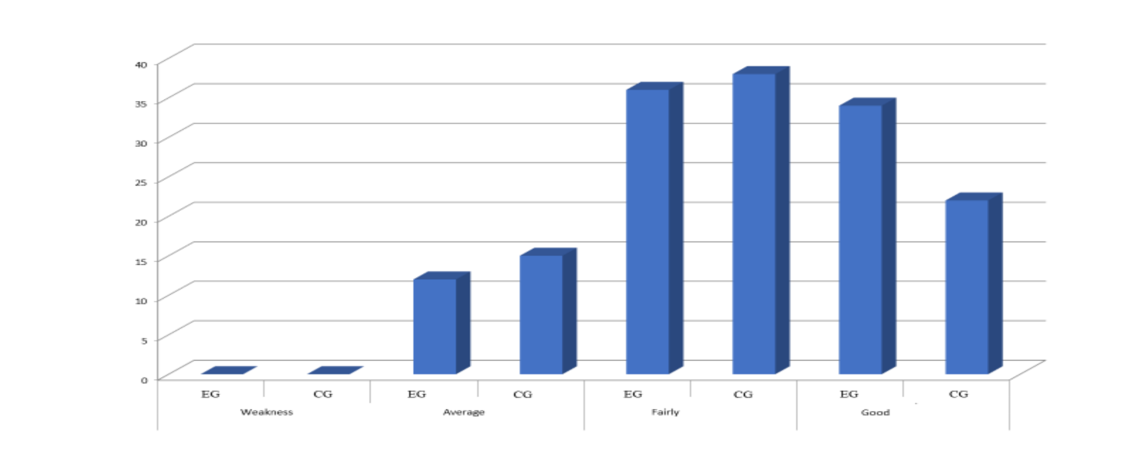

Figure 2. 45-minute test score aggregate result classification

Chart 2 shows that the pass rate of the EG class is higher than that of the CG class.

Table 4. Compilation of characteristic parameters through a 45-minute test

High School	**Nam Tien Hai**		**Nguyen Viet Xuan**	
Class	EG1	CG1	EG2	CG2
Mode	9.0	9.0	8.0	7.0
Median	8.0	8.0	8.0	7.5
Average plus	8.40	7.82	7.54	7.50
Standard deviation (S)	1.07	1.22	1.19	1.42
Variance	1.15	1.49	1.40	2.02
Value p	0.005	0.004	<.001	<.001
Effect Sizes (ES)	1.50		1.61	

From Table 4, it can be seen that the average value of the EG class is higher than that of the CG class. This difference is significant, possibly replicating the impact caused by (ES >0.5).

During the pedagogical experiments process, we evaluated the students' self-learning competency in 2 EG and obtained the following results:

Results of the evaluation of the manifestations of the students

Table 5. Evaluation results of students' self-learning competency

Numerical criteria	**Post-impact experimental**				**Pre-impact experimental**			
	Number of students who scored			***Criteria GPA***	***Number of students who scored***			***Criteria GPA***
	1	***2***	***3***		***1***	***2***	***3***	
1	8	31	43	2.43	47	23	12	1.57
2	8	29	45	2.45	45	25	12	1.60
3	14	24	44	2.37	51	18	13	1.54
4	6	29	47	2.50	45	23	14	1.62
5	10	30	42	2.39	46	22	14	1.61
6	12	29	41	2.35	50	20	12	1.54
7	16	28	38	2.27	39	25	18	1.74
8	10	28	44	2.41	47	20	15	1.61
9	15	28	39	2.29	42	24	16	1.68
10	12	28	42	2.37	46	21	15	1.62
Average score of the self-learning competency of the post-impact experimental class				2.40	Average score of the self-learning competency of the pre-impact experimental class			1.60
The standard deviation of the EG class after impact				0.57	Standard deviation of the EG class before impact			0.77
Independent t-test verification: $p=1,16.10^{-5}$								
ES Influence Level = 1,03								

2.5.3. Evaluation of the results obtained

Qualitative assessment

- Passing the results of the post-EG test to effectively assess the ability to absorb knowledge, synthesize, analyze, and apply knowledge to solve relevant problems in practice and life. The results of the EG class have a higher score than the CG class. The level of initiative, self-learning, and creativity of EG students is higher than that of the Primary class.

- Through statistics of self-learning competency manifestations: During the 1st pedagogical experiment, most of the students in the classroom were passive, taking notes according to what the teacher taught in class, very few students had obvious manifestations of self-learning competency, knowing how to self-study were usually quite good students. The manifestations of self-learning capacity in those students are mostly obtained through the accumulation of experience in the process of self-study. During the 2nd pedagogical experiment, most of the students were guided and practiced self-study skills, so they all gave very positive results.

- In addition, in terms of the spirit and learning attitude of students, we noticed the following:

Different from the psychology of timidity and apprehension when speaking or presenting in front of the class, after being trained through 2 pedagogical experiments, EG students are more proactive, active, self-reliant, and creative in learning than the CG class.

From the above results, it can be seen that the flipped classroom model effectively supports self-learning competency for students. This can confirm that the scientific hypothesis of the thesis is completely correct, feasible, and effective.

. *Quantitative evaluation*

Based on the results of pedagogical experiments, it is shown that the quality of learning after the experiment of students in the EG class is higher than that of students in the first grade, as shown below:

- The accumulation line of EG classes is always located on the right side, and below the accumulation line of EG classes, indicating that the learning results of students in EG classes are better than in CG classes.

- The average score through the tests of the EG classes is higher than that of the CG classes, proving that the knowledge acquisition results of the EG class are higher than those of the CG class.

- Through the test of – independent test $p < 0.05$, it was shown that the difference in the average score of the post-experimental tests of the EG class and the CG class was not likely to occur randomly. The ES value in the range of 1.5 – 1.61 (Cohen criterion table) proves that the scale of influence is average; this study can replicate the impact measure of the thesis.

Analysis of the results of the assessment of self-learning competency development for students based on evaluation sheets according to the criteria

- Through the evaluation criteria in the process of training students' self-learning competency, we can see a clear development of students' self-learning competency through each pedagogical experiment.

- Through students' self-assessment, it is shown that students have also realized that self-study has helped students practice many new skills, so there is a clear increase in the results of the criteria.

- Thus, through the results of pedagogical experiments, it can be said that the application of the reverse classroom model to develop self-learning competency for students has achieved certain effects.

3. Conclusions

The findings of this study underscore the effectiveness of the flipped classroom model in enhancing the self-learning competency of Grade 10 students in chemistry. The experimental group, which participated in the flipped classroomintervention, demonstrated clear improvements in both academic performance and self-directed learning abilities compared to the control group. Quantitative analysis revealed statistically significant differences in outcomes, with p-values consistently below 0.005 across all tested comparisons. Importantly, the effect sizes (ES) ranged from 0.59 to 1.61, indicating a strong and meaningful impact of the intervention. Through the implementation of this innovative pedagogical approach, students demonstrated significant improvements in both their academic performance and engagement levels. The experimental group, which was exposed to a learning environment that encouraged self-learning, outperformed the control group in post-test assessments. This suggests that the "Flipped classroom"model not only fosters a deeper understanding of complex concepts such as "Chemical energy" and "Reaction rate" but also cultivates essential skills needed for self-directed learning.

Moreover, qualitative feedback from students revealed a marked increase in their motivation and confidence to take ownership of their learning. Many students reported feeling more proactive in their studies, as they engaged with instructional materials at their own pace and actively participated in classroom discussions. This shift from passive to active learning is crucial in developing critical thinking and problem-solving skills, which are vital for success in today's rapidly changing educational landscape.

The results of this research contribute to the growing body of evidence supporting the flipped classroom model as a viable alternative to traditional teaching methods, particularly in the sciences. By effectively addressing the limitations of conventional approaches, the flipped classroomempowers students to become autonomous learners, capable of navigating and applying their knowledge in real-world contexts. Therefore, this study not only highlights the potential of the flipped classroom model to enhance educational outcomes but also encourages educators to consider innovative strategies that align with modern educational goals. Future research could further explore the long-term impacts of the flipped classroom model on students' self-learning competency across different subjects and academic levels.

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