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The Flipped Classroom Model and the Impact of Perseverance on Developing Mathematics Self-Learning Competency in Vietnam

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Abstract:

The adoption of the flipped classroom (FC) model in Vietnam has gained significant momentum, particularly in response to ongoing educational reforms and the broader digital transformation of learning environments. This study employs a quantitative research design, utilizing a rigorously developed and expert-validated questionnaire to survey 394 teachers and 460 middle school students. Data analysis using SPSS based in Structure equation model (SEM) theory to confirms the viability of the FC model and identifies five key factors influencing middle school students' self-learning competency (SLC) in mathematics, examine the relationships between self-learning and factors of 1) Planning (0.292), 2) Methods (0.174), 3) Technology & Learning Resources (0.116), 4) Assessment (0.229), and 5) Perseverance (0.304). Among these, perseverance emerges as the most influential factor (30.4%), underscoring the crucial role of emotional resilience and intrinsic motivation—dimensions that have been largely overlooked in previous research.

The study underscores the challenges of implementing the FC model in Vietnam, where traditional teaching prioritizes rote memorization and passive learning. Transitioning to the FC approach requires students to engage with content pre-class and develop perseverance for autonomous, cognitively demanding learning—particularly in mathematics, which demands logical reasoning and problem-solving. Maximizing the FC model's benefits in the digital era necessitates collaboration among educators, institutions, policymakers, and students. Integrating technology with evidence-based pedagogy enhances instruction, fosters independent learning, and promotes lifelong learning. This study offers insights into self-learning development and strategies for optimizing FC implementation across educational contexts.

Keywords: flipped classroom, self-learing mathematics, perseverance, secondary student

1. Introduction

In the context of ongoing educational reforms, the development of students' self-learning abilities has emerged as a critical imperative, particularly in Mathematics—an academic discipline that necessitates logical reasoning and active knowledge acquisition. To address this challenge, the Flipped Classroom model has been extensively studied and implemented worldwide as an innovative pedagogical approach aimed at enhancing learning outcomes and fostering student autonomy.

Empirical research underscores the pivotal role of the Flipped Classroom model in cultivating students' self-directed learning and initiative. By engaging with instructional materials such as pre-recorded video lectures and supplementary resources prior to in-class sessions, students are afforded the opportunity to conduct independent inquiry and establish a foundational understanding of key concepts. This preparatory phase not only reinforces self-learning capabilities and critical thinking skills but also optimizes classroom interactions. Rather than passively receiving knowledge through traditional lecturing, students actively participate in collaborative discussions, problem-solving exercises, and hands-on applications, thereby improving their cognitive retention and conceptual mastery (Bergmann & Sams, 2012).

Furthermore, the Flipped Classroom model promotes a flexible learning environment that enables students to regulate their own pace of study, revisit instructional content multiple times, and seek clarification as needed. This pedagogical approach enhances students' time management skills and fosters a heightened sense of academic responsibility. Additionally, it encourages engagement in group discussions and cooperative learning tasks, thereby nurturing essential competencies such as critical thinking and teamwork—attributes that are fundamental to the study of Mathematics and other STEM-related disciplines (Bishop & Verleger, 2013).

Despite its pedagogical benefits, the implementation of the Flipped Classroom model presents several challenges. Primarily, it necessitates a high level of self-regulation and motivation among students. Learners who lack prior exposure to self-directed study methods may encounter difficulties in comprehending instructional materials independently, leading to inadequate preparation for in-class activities and diminished overall learning effectiveness. Furthermore, the successful adoption of this model is contingent upon access to technological infrastructure, including digital devices and stable internet connectivity. For students from economically disadvantaged backgrounds, these prerequisites may pose significant barriers to participation, thereby exacerbating educational inequalities (Hamdan et al., 2013).

Another critical concern pertains to the disparities in students' learning abilities. Those who exhibit slower learning paces or struggle with self-guided study may be at risk of falling behind without timely pedagogical support. Moreover, the implementation of the Flipped Classroom model imposes substantial demands on educators, requiring them to invest considerable time and effort in the design and curation of digital instructional content, as well as the facilitation of interactive classroom activities (O'Flaherty & Phillips, 2015). Consequently, to maximize the efficacy of this approach, it is imperative to integrate a diverse array of instructional strategies that enhance students' self-learning competencies and mitigate potential obstacles.

Fostering effective self-learning skills in Mathematics represents both an essential and complex pedagogical objective. To equip students with robust self-directed learning capabilities, comprehensive research is required to examine the factors influencing this process and to develop targeted interventions. One of the most critical determinants of self-learning success is perseverance—a fundamental attribute that enables students to navigate academic challenges, sustain motivation, and achieve long-term learning goals.

A pertinent question arises: how can perseverance be cultivated and maintained in the learning process, particularly in Mathematics, a subject that demands sustained logical reasoning and problem-solving proficiency? To address this inquiry, the present study investigates the barriers that hinder students' self-learning development and proposes a structured support framework for both educators and learners.

In addition to exploring the effectiveness of the Flipped Classroom model as a contemporary instructional methodology, this study underscores the significance of perseverance in self-learning. It further presents evidence-based pedagogical strategies to enhance the implementation of the Flipped Classroom model, strengthen students' self-learning capacities, and sustain their intrinsic motivation for academic achievement.

2. Literature Review

2.1 The Flipped Classroom Model

Global Perspective

The Flipped Classroom (FC) model has emerged as a transformative approach to education, rooted in the learner-centered paradigm. King (2015) underscored the importance of fostering critical thinking and problem-solving skills, shifting away from passive knowledge transmission. This concept was further developed by Mazur (Harvard), who pioneered the "Peer Instruction" methodology, wherein students engage with content prior to class and utilize interactive tools for in-class discussions and activities.

Building on these foundations, Lage, Platt, and Treglia (2000) introduced an FC model incorporating pre-class video lectures to optimize classroom engagement, while Baker (2000) integrated online tools to enhance flipped instruction. The model gained prominence through the work of Bergmann and Sams (2012), who expanded its application, enabling students to access instructional content flexibly and fostering interactive learning experiences.

The proliferation of digital education was significantly influenced by Kundi & Khan (2010), whose development of Khan Academy provided freely accessible educational resources and promoted self-directed learning. Subsequent studies, including those by Debbağ & Yıldız (2021) and Bishop and Verleger (2013), systematically examined the effectiveness of the FC model, identifying both its pedagogical advantages and the challenges associated with its implementation. More recent research has delved into its broader implications, with scholars such as López Belmonte (2019) and Cevikbas and Kaiser (2020) investigating its impact on student motivation, interaction, and technological integration in teaching.

As an advanced instructional strategy, the FC model has been recognized for prioritizing learner-centered engagement and fostering active participation. Agyeman and Aphane (2024) assert that FC departs from traditional teaching methodologies by enabling students to engage with instructional materials, including videos and readings, before attending class. Consequently, classroom time is allocated to collaborative problem-solving, discussions, and knowledge application, leading to deeper learning experiences (Yang et al., 2023).

Empirical research consistently highlights the benefits of FC in enhancing learning outcomes, particularly in the development of critical thinking and student motivation (Salas-Rueda, 2020; Meyliana et al., 2021). The integration of digital tools within the FC framework further personalizes learning experiences and provides real-time feedback, facilitating more effective and independent learning (Guo, 2019).

Despite its advantages, the implementation of FC is not without challenges. Key issues include disparities in technological accessibility, variations in student preparedness, and the need for faculty training to ensure successful adoption (Debbağ & Yildiz, 2020). To maximize the efficacy of FC, scholars recommend that instructors employ structured teaching strategies, develop engaging instructional materials, and implement continuous assessment mechanisms to support student learning (Talan & Gülseçen, 2019).

Looking ahead, future research should explore the potential of artificial intelligence (AI) in personalizing learning experiences and optimizing interdisciplinary applications of the FC model (Ribeiro et al., 2025; Thomas & S, 2024). With the ongoing evolution of educational methodologies, FC presents significant potential to revolutionize traditional learning environments, fostering active knowledge acquisition, skill development, and sustainable academic success.

Vietnamese Perspective

In Vietnam, research on the FC model has focused on its application across different educational levels and subject areas. Early studies, such as those conducted by Nguyễn Văn Lợi (2014), examined the advantages and limitations of FC, while later investigations by Hung & Tuan (2022) designed experimental lesson plans utilizing digital tools such as Microsoft Teams and Chemsketch.

More recent contributions include research by Phạm Thị Nga et al. (2023), who proposed a flexible FC model for Mathematics that integrates both traditional and active learning methodologies. Empirical findings from Vietnamese studies suggest that FC enhances student engagement, critical thinking, and collaborative learning (Tuấn & Ninh, 2023). Moreover, the model has been shown to cultivate greater student autonomy in pre-class content review, leading to improved knowledge retention and application in practical contexts (Phạm T. Nga, 2024).

Nevertheless, the implementation of FC in Vietnam faces several challenges. Among these, technological disparities between urban and rural areas pose significant barriers to equitable access. Additionally, faculty readiness to adopt innovative teaching methods remains inconsistent (Luong & Hung, 2023). Further research by Minh & Trang (2024) indicates that while students appreciate the flexibility inherent in FC, they often struggle with self-regulated learning and effective time management.

To optimize the adoption of FC in Vietnam, scholars advocate for the integration of technology platforms tailored to local educational contexts and the provision of faculty development programs to enhance instructional design and pedagogical guidance (Nguyễn & Lê, 2024). Moreover, the exploration of AI-driven content personalization is emerging as a promising avenue for enriching learning experiences and improving educational outcomes (Ly T, 2025).

Although FC has been introduced at all educational levels in Vietnam, research on its application to specific subject areas remains limited. Given the emphasis on active learning in the 2018 General Education Curriculum, FC presents a compelling pedagogical strategy for aligning with national educational reform objectives. Further empirical studies are needed to assess its long-term impact on student achievement and instructional effectiveness within the Vietnamese educational landscape.

2.2 Recent Research on the Flipped Classroom Model in Mathematics Education

The Flipped Classroom (FC) model has gained considerable attention as an innovative pedagogical approach in mathematics education, particularly at the secondary level. This instructional method reconfigures traditional teaching structures by delivering course content through digital materials, such as video lectures, which students engage with independently before class. This restructuring optimizes classroom time for interactive discussions, problem-solving activities, and personalized teacher guidance. Contemporary research efforts have focused on evaluating the effectiveness of this model, identifying key instructional design factors, and addressing challenges associated with its implementation in secondary mathematics education.

Empirical studies have consistently demonstrated that the FC model yields positive effects on students' learning outcomes and engagement levels. Students in FC environments tend to outperform their counterparts in traditional classrooms, particularly in problem-solving skills and conceptual comprehension (Lapitan et al., 2023; Rohmatulloh et al., 2022). For instance, a study conducted in China reported significant improvements in mathematics achievement, particularly among students with average academic performance (Wei et al., 2020). Similarly, research in the Philippines revealed that FC implementation led to higher test scores, reflecting enhanced academic performance (Baybayan & Cabanes, 2024). Beyond academic achievement, the FC model has been shown to foster student motivation and participation. A study in Turkey indicated that students perceived the FC environment as more interactive and collaborative, leading to reduced anxiety and heightened engagement in mathematics learning (Divjak, et al,. 2022). Moreover, research in Malaysia found that the FC model bolstered students' confidence and motivation, particularly in algebra, with a notable increase in student satisfaction (Tampi, 2024; (Adriani & Mulyani, 2022).

The successful implementation of the FC model is contingent upon several critical factors. Firstly, pre-class learning materials, including high-quality video lectures and interactive content, play a pivotal role in preparing students for in-class discussions and problem-solving activities (Li et al., 2023; Palmero et al., 2023). Furthermore, in-class activities should be designed to foster active learning, promote collaboration, and provide personalized support, thereby enabling educators to effectively address individual student needs (Martin et al., 2016; Neycheva, 2023). Technological integration is another essential component of FC implementation. Digital tools such as online quizzes, multimedia resources, and interactive applications enhance flexible, self-paced learning experiences (Brown et al., 2022; Putra et al., 2024). However, the effectiveness of FC depends significantly on the quality and alignment of these technological tools with instructional objectives (Ruiz-Palmero et al., 2023).

Despite its numerous advantages, the FC model is not without challenges. One significant barrier is its reliance on digital technology, which may pose difficulties for students with limited access to digital resources at home (Baybayan & Cabanes, 2024). Additionally, the development of high-quality instructional materials, such as video lectures and interactive content, requires substantial time and effort from educators, potentially hindering widespread adoption (Ruiz-Palmero et al., 2023). Teacher training is another critical factor, as instructors must be adequately prepared to design engaging digital content, facilitate active learning, and effectively manage FC environments (Brown et al., 2022; Yarim & Ada, 2023). Moreover, the integration of the FC model into existing curricula and assessment frameworks requires strategic modifications and coordinated efforts among educational administrators (Neycheva, 2023).

In conclusion, the Flipped Classroom model presents a promising approach to mathematics education at the secondary level by fostering personalized learning, increasing student engagement, and improving academic achievement. However, successful implementation necessitates meticulous instructional design, robust technological infrastructure, and comprehensive professional development for educators. When thoughtfully adapted and effectively integrated into educational systems, the FC model has the potential to bring substantial improvements to mathematics education, catering to the diverse learning needs of students.

2.3 The Role of the Flipped Classroom Model in Developing Students' Self-Directed Learning Skills and Vice Versa

The Flipped Classroom (FC) model serves as a transformative pedagogical approach that significantly contributes to the development of students' self-directed learning (SDL) skills. By shifting instructional content delivery to pre-class activities through digital resources such as video lectures and reading materials, the model fosters autonomy, critical thinking, and self-regulated learning. Engaging with instructional materials before attending class enables students to cultivate proactive learning habits, enhance self-discipline, and refine time management skills. Furthermore, FC facilitates personalized learning, allowing students to control their learning pace, leading to deeper comprehension and reinforcement of independent study habits. Within the classroom setting, this model encourages active participation in discussions, collaborative problem-solving, and group work, all of which contribute to the development of critical thinking and analytical skills. Additionally, students gain proficiency in retrieving and evaluating information from diverse sources, a fundamental aspect of SDL. The FC model also supports self-assessment, creativity, and inquiry-based learning by motivating students to formulate questions and explore solutions to academic challenges. More importantly, it instills lifelong learning skills, providing a foundation for continuous and sustainable self-education.

Conversely, the integration of SDL strategies into the FC model enhances its effectiveness as an innovative instructional approach in secondary mathematics education. By shifting from a traditional lecture-based paradigm to a learner-centered environment, FC enables students to acquire new knowledge independently before applying it in structured, interactive classroom settings under teacher guidance. This pedagogical shift aligns with contemporary educational methodologies and technological advancements, further strengthening students' capacity for self-regulated learning. SDL plays a pivotal role in this process by fostering critical thinking, independence, and intrinsic motivation, ultimately driving creativity and active engagement in mathematical exploration (Joshi & Luitel, 2024).

Moreover, the FC model enhances student-teacher interactions and facilitates differentiated instruction, thereby catering to diverse learning needs while simultaneously promoting logical reasoning and problem-solving skills (Stapleton, 2020; Rodríguez & Ruiz, 2020). Collaborative learning is another key benefit, as peer discussions enable students to exchange alternative problem-solving strategies, thereby deepening their conceptual understanding (Stapleton, 2020). However, despite its numerous advantages, the effectiveness of the FC model is subject to several challenges. Inconsistencies in instructional design and classroom activity implementation can impede student learning outcomes. Furthermore, resistance from students, parents, and educators may hinder widespread adoption of this model (Fung et al., 2021; Stapleton, 2020).

To ensure the successful implementation of the FC model, meticulous planning, well-structured classroom activities, and a commitment from all educational stakeholders are essential. Additionally, a high degree of self-directed learning is imperative for students to fully adapt to this innovative instructional approach. When effectively designed and integrated, the FC model has the potential to revolutionize mathematics education by fostering deeper learning, enhancing student engagement, and equipping learners with essential lifelong skills.

3. Research Methodology

This study seeks to systematically assess the challenges encountered by teachers in implementing the flipped classroom (FC) model, as well as the difficulties faced by Vietnamese students in self-directed learning. Furthermore, it examines the extent to which various factors influence students' self-learning capacity, with the objective of proposing effective pedagogical solutions.

To achieve these aims, a survey research method was adopted, involving a sample of 394 teachers and 460 lower secondary school students. The survey instruments were carefully designed to ensure the validity and reliability of the data collected. Specifically, the teacher questionnaire comprised three core questions alongside a structured assessment of self-learning capacity components. Meanwhile, the student questionnaire contained two meticulously formulated questions, developed with reference to existing literature and refined through expert review by Vietnamese scholars.

Data collection was followed by a rigorous analytical process using Excel and SPSS software. These tools facilitated the synthesis and interpretation of data, enabling a comprehensive evaluation of the difficulties associated with implementing the FC model, the obstacles students face in self-directed learning, and the impact of key influencing factors on students' self-learning capacity. By employing this methodological approach, the study ensures the robustness and credibility of its findings.

The research investigation was structured around the following focal areas:

- The challenges teachers encounter in adopting the flipped classroom model.
- The difficulties students face in self-directed learning and their need for academic support from teachers and schools.
- The influence of various factors on the development of students' self-learning capacity.

This methodological framework provides a solid foundation for understanding the complexities of the flipped classroom model in the Vietnamese educational context, offering valuable insights for future pedagogical improvements.

4. Findings

4.1. Survey on the Flipped Classroom Model

Table 1. Challenges in Implementing the Flipped Classroom Model

Challenges	Number of Teachers Selecting	Percentage	Rank
Time-consuming	257	65.2%	1
Teachers' technological and IT skills are not proficient	17	4.3%	5
Lack of equipment	128	32.5%	3
Students do not know how to access and use online materials	94	23.9%	4
Students lack self-learning skills	231	58.6%	2

Challenges	Number of Teachers Selecting	Percentage	Rank
Other opinions	0	0%	-

The survey results indicate that some teachers face difficulties in applying the flipped classroom model. Among these challenges, 65.2% of teachers reported that this model requires significant time for preparing materials and designing activities. Additionally, 58.6% of teachers stated that students lack self-learning skills. Therefore, fostering students' self-learning skills is crucial, particularly in a flipped learning environment.

4.2. Survey on Self-Study

Table 2. Some Difficulties Students Face in Self-Study

Content	Teachers (N=394)	Students (N=460)
	Number of Selections	Percentage
Lack of motivation and interest	384	97.5%
Not knowing how to create a self-study plan	275	69.8%
Lack of materials and learning equipment	198	50.3%
Insufficient time for self-study	60	15.2%
Not fully understanding the lesson content	94	23.9%
Not knowing how to self-evaluate	317	80.5%
Other opinions	0	0%

Both teachers and students acknowledge several critical challenges associated with self-study, including a lack of motivation and interest, difficulty in developing a structured study plan, and an inability to self-evaluate. Notably, students encounter the greatest difficulties in formulating a self-study plan (47.8%), assessing their own progress (45.4%), and sustaining motivation and interest in learning (43.7%).

In addition to these primary obstacles, a small number of students identified further difficulties in self-studying mathematics, such as procrastination, lack of concentration, and an inability to find enjoyment in the subject.

Given these challenges, fostering motivation, passion, enthusiasm, and perseverance is essential to enhancing students' self-study effectiveness. When students are intrinsically motivated and actively engaged in the learning process, they are more likely to develop a genuine interest in mathematics, which, in turn, cultivates self-discipline, independent thinking, confidence, and a sense of responsibility for their academic progress.

The survey findings also highlight that many students have not yet acquired the skills necessary to plan their self-study or conduct self-evaluations effectively. To address this, educators should implement targeted interventions and provide structured guidance to help students develop essential self-study competencies, thereby fostering greater autonomy and academic success.

Table 3. Areas Where Students Need Support in Self-Study

Content	**Teachers (N=394)**	**Students (N=460)**
	Number of Selections	Percentage
Guidance on developing study plans and self-study management	368	93.4%
Enhancing digital and technological skills	85	21.6%
Ensuring adequate study materials and learning equipment	189	48.0%
Providing timely feedback when students face difficulties	291	73.9%
Guidance on self-evaluation	334	84.8%
Other opinions	0	0%

Both teachers and students underscore the critical need for guidance in study planning, self-management, self-evaluation, and timely feedback to support students in overcoming challenges. Specifically, **93.4% of teachers and 62.0% of students** emphasize the necessity of assistance in developing self-study plans, **84.8% of teachers and 47.6% of students** highlight the importance of self-evaluation guidance, and **73.9% of teachers and 54.3% of students** stress the significance of receiving timely feedback.

Despite the implementation of the **Learner-Centered Teaching Model (LCTM)** in general education, its effectiveness remains hindered by several obstacles, including limited access to high-quality study materials, inadequate technical support, and the need to enhance students' self-directed learning competencies. These challenges are particularly pronounced in mathematics education, where teachers must prioritize the development of comprehensive learning resources, the design of engaging instructional activities, and the integration of active learning strategies to foster student interest and improve academic performance.

Thus, it is imperative to implement targeted interventions that equip students with essential self-study skills while simultaneously cultivating motivation and self-evaluation abilities. Strengthening these competencies will ultimately contribute to more effective, autonomous, and self-regulated learning.

4.3. Model validation for self-learning competency development

4.3.1. Proposed model"

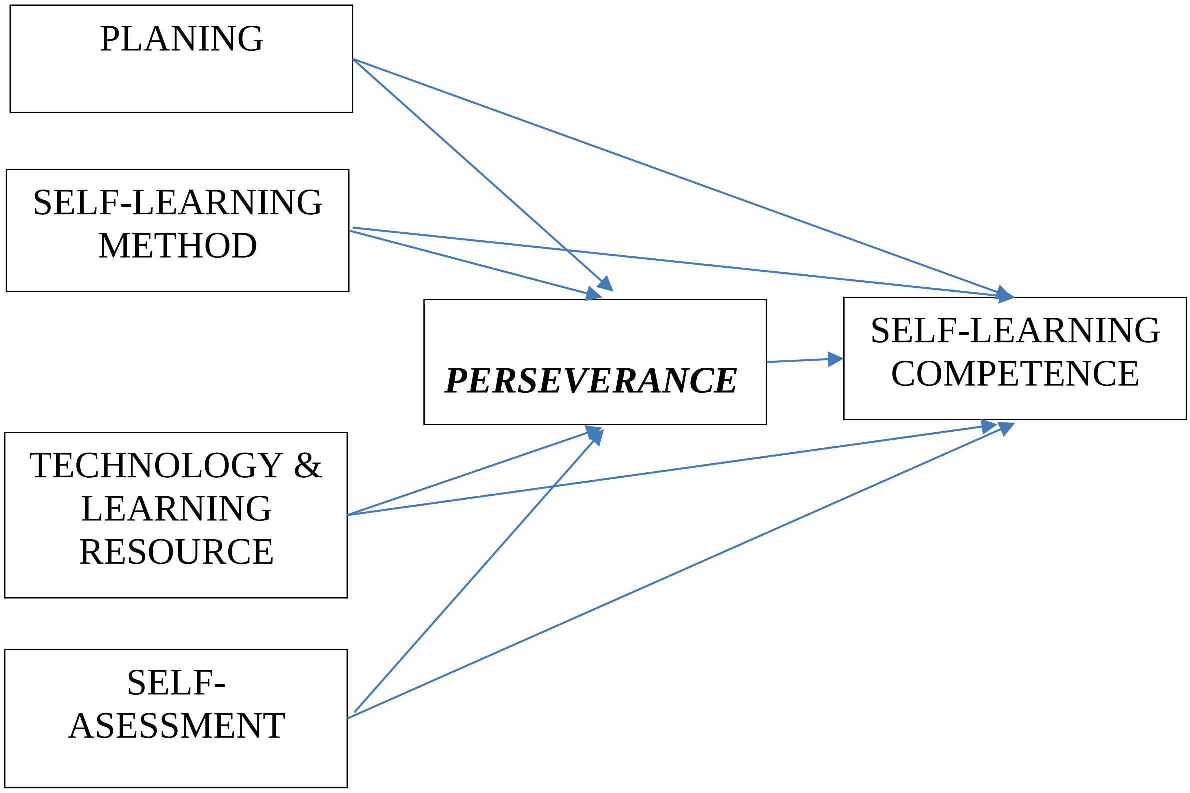

Figure 1. Proposed model of Self-learning competency

Table 4. Questionnaire of Impact Criteria Impact Level

Factor 1: PLANNING

Developing and flexibly implementing personal study plans (**LKH**)

- **LKH1**: Recalling previous self-study experiences.
- **LKH2**: Identifying learning objectives.
- **LKH3**: Allocating study time effectively.
- **LKH4**: Flexibly adjusting the study plan.
- **LKH5**: Tracking progress in study plan implementation.

Factor 2: METHODS

Selecting and effectively applying appropriate learning methods and techniques (**PP**)

- **PP1**: Recalling previously used self-study methods.
- **PP2**: Choosing suitable learning methods.
- **PP3**: Actively exploring learning methods and techniques from others.

- **PP4**: Modifying study methods when previous approaches prove ineffective.
- **PP5**: Combining different learning methods to improve outcomes.

Factor 3: TECHNOLOGY AND LEARNING RESOURCES

Searching, synthesizing, and effectively utilizing learning resources and information technology for study and self-improvement (**HLVCN**)

- **CNVHL1**: Recalling past experiences in searching for learning materials and using technology in self-study.
- **CNVHL2**: Proactively seeking additional materials to expand knowledge.
- **CNVHL3**: Learning how to use tools and software to support learning.
- **CNVHL4**: Effectively utilizing online resources (videos, e-books, etc.) in the learning process.
- **CNVHL5**: Synthesizing knowledge from multiple sources.
- **CNVHL6**: Using technology to exchange ideas and learn from study groups (peers, teachers).
- **CNVHL7**: Selecting and evaluating the quality of learning resources.

Factor4: SELF-EVALUATION

Assessing oneself to recognize strengths and weaknesses for improvement (**ĐG**)

- **ĐG1**: Self-assessing learning outcomes.
- **ĐG2**: Clearly identifying strengths and weaknesses in the learning process.
- **ĐG3**: Developing improvement plans based on self-evaluation results.
- **ĐG4**: Adjusting learning methods when weaknesses are identified.
- **ĐG5**: Reviewing study plans and learning outcomes after each lesson/test for continuous improvement.

Factor 5: PERSEVERANCE

Maintaining effort and persistence in self-study, especially when facing difficulties or obstacles (**KT**)

- **KT1**: Regularly reminding oneself of self-study tasks to be completed.
- **KT2**: Learning self-study strategies from others or instructional books.
- **KT3**: Reflecting on self-study methods and outcomes after each learning phase for improvement.
- **KT4**: Using personal note-taking techniques, recording, or capturing images to summarize and remember key points.
- **KT5**: Seeking relevant self-study resources aligned with learning objectives.
- **KT6**: Striving to solve problems independently while knowing when to seek help from peers or teachers.

SELF-STUDY COMPETENCY

Overall evaluation of the impact of these factors on students' self-study competencies (**NLTH**).

4.3.2 Data Analysis Results

To assess the reliability of the measurement scale, we employed Cronbach's Alpha coefficient in combination with Exploratory Factor Analysis (EFA). Variables with a Cronbach's Alpha coefficient below 0.7 require reconsideration (Taber, 2018), while those with a Corrected Item-Total Correlation coefficient lower than 0.3 must be eliminated (Nunnally & Bernstein, *The Assessment of Reliability*, 1994). After analyzing the data using SPSS, we removed item **CNVHL7**, as its Corrected Item-Total Correlation coefficient was 0.169 (< 0.3). The final Cronbach's Alpha coefficients for the five variables are summarized in the table below:

Table 8. Cronbach's Alpha Analysis Results

Competency Component	Independent Variable	Cronbach's Alpha	Mean
Planning	LKH (LKH1, LKH2, LKH3, LKH4, LKH5)	0.926	3.780
Methods	PP (PP1, PP2, PP3, PP4, PP5)	0.852	3.704
Technology and Learning Resources	CNVHL (CNVHL1, CNVHL2, CNVHL3, CNVHL4, CNVHL5, CNVHL6)	0.894	3.591
Self-Evaluation	ĐG (ĐG1, ĐG2, ĐG3, ĐG4, ĐG5)	0.871	3.435
Perseverance	KT (KT1, KT2, KT3, KT4, KT5, KT6)	0.874	3.618

The results demonstrate that the Cronbach's Alpha coefficients range from good to excellent, affirming the reliability of the measurement scale. Furthermore, the mean values indicate a relatively strong impact of these competency components on self-learning ability.

Subsequently, an Exploratory Factor Analysis (EFA) was conducted using key criteria, including the Kaiser-Meyer-Olkin (KMO) coefficient, Bartlett's test of sphericity, Eigenvalue, Total Variance Explained, and Factor Loadings. The EFA is deemed appropriate when the KMO coefficient falls between 0.5 and 1 (Hair et al., 2019).

Bartlett's test of sphericity assesses whether the observed variables within a factor are correlated. A statistically significant result (Sig. Bartlett's Test < 0.05) confirms the presence of correlations among the observed variables in the dataset.

To be retained in the analysis model, an Eigenvalue must be at least 1. Additionally, the Total Variance Explained should exceed 50% (Gerbing & Anderson, 1988). Factor loadings must be ≥ 0.5 within the same factor, and any observed variable with a factor loading below this threshold is excluded from the model (Hair et al., 2019).

Table 9. Results of KMO Coefficient Testing

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,903
Bartlett's Test of Sphericity	Approx. Chi-Square	8831,351
	df	351
	Sig.	,000

The KMO coefficient of 0.903 indicates excellent sampling adequacy, confirming that the dataset is suitable for factor analysis. Bartlett's test of sphericity yields a significance value (Sig) of 0.000, suggesting that the observed variables are significantly correlated. The analysis identifies five factors, extracted based on an Eigenvalue greater than 1, effectively summarizing the information from the 27 observed variables included in the EFA. These five factors collectively explain 71.172% of the total variance, surpassing the 50% threshold, thereby demonstrating their strong explanatory power in capturing the variability within the dataset.

Table 10. Rotated Component Matrixa (Varimax Rotation)

	Component				
	1	2	3	4	5
LKH4	,884				
LKH5	,882				
LKH2	,858				
LKH1	,648				
LKH3	,616				
KT6		,830			
KT4		,775			
KT3		,726			
KT1		,683			
KT5		,652			
KT2		,646			
CNVHL5			,856		
CNVHL6			,797		
CNVHL3			,684		
CNVHL1			,676		
CNVHL2			,642		
CNVHL4			,628		
PP3				,814	
PP2				,796	
PP4				,722	
PP5				,680	

PP1				,653	
ĐG5					,685
ĐG4					,646
ĐG3					,611
ĐG2					,578
ĐG1					,532

The results indicate that all factor loadings are greater than 0.5, ensuring both differentiation and convergence. The five expected components are clearly distinguished (excluding the first column, which contains variable names), with variables such as LKH1, LKH2, LKH3, LKH4, and LKH5 clustering under the same factor, and similar patterns observed for other variables.

Development of a Multiple Regression Equation

Constructing Representative Variables:

- **LKH** = mean (LKH1, LKH2, LKH3, LKH4, LKH5)
- **PP** = mean (PP1, PP2, PP3, PP4, PP5)
- **CNVHL** = mean (CNVHL1, CNVHL2, CNVHL3, CNVHL4, CNVHL5, CNVHL6)
- **ĐG** = mean (ĐG1, ĐG2, ĐG3, ĐG4, ĐG5)
- **KT** = mean (KT1, KT2, KT3, KT4, KT5, KT6)

Running Pearson Correlation Analysis

Table 11. Pearson Correlation Analysis

		NLTH	LKH	PP	CNVHL	ĐG	KT
NLTH	Pearson Correlation	1	,745**	,617**	,634**	,769**	,748**
	Sig. (2-tailed)		,000	,000	,000	,000	,000
	N	394	394	394	394	394	394
LKH	Pearson Correlation	,745**	1	,456**	,635**	,613**	,528**
	Sig. (2-tailed)	,000		,000	,000	,000	,000
	N	394	394	394	394	394	394
PP	Pearson Correlation	,617**	,456**	1	,400**	,519**	,477**
	Sig. (2-tailed)	,000	,000		,000	,000	,000
	N	394	394	394	394	394	394

CNVHL	Pearson Correlation	,634**	,635**	,400**	1	,558**	,447**
	Sig. (2-tailed)	,000	,000	,000		,000	,000
	N	394	394	394	394	394	394
ĐG	Pearson Correlation	,769**	,613**	,519**	,558**	1	,677**
	Sig. (2-tailed)	,000	,000	,000	,000		,000
	N	394	394	394	394	394	394
KT	Pearson Correlation	,748**	,528**	,477**	,447**	,677**	1
	Sig. (2-tailed)	,000	,000	,000	,000	,000	
	N	394	394	394	394	394	394

**. Correlation is significant at the 0.01 level (2-tailed).

The results indicate that all independent variables are positively correlated with each other. Moreover, all independent variables exhibit a strong correlation with NLTH (self-learning ability). Therefore, all independent variables—LKH, PP, CNVHL, ĐG, and KT—are retained.

Multiple Linear Regression

Table 13. Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,895[a]	,801	,799	,302	1,967

a. Predictors: (Constant), KT, CNVHL, PP, LKH, ĐG
b. Dependent Variable: NLTH

Table 14. ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	142,482	5	28,496	313,261	,000[b]
	Residual	35,295	388	,091		
	Total	177,777	393			

a. Dependent Variable: NLTH
b. Predictors: (Constant), KT, CNVHL, PP, LKH, ĐG

Table 15. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	,130	,095		1,370	,171		

	LKH	,216	,024	,292	8,928	,000	,479	2,089
	PP	,123	,019	,174	6,319	,000	,677	1,476
	CNVHL	,098	,026	,116	3,786	,000	,548	1,825
	ĐG	,218	,034	,229	6,492	,000	,411	2,433
	KT	,321	,034	,304	9,559	,000	,506	1,976

a. Dependent Variable: NLTH

In **Table 13**, the correlation coefficient r=0.895r = 0.895r=0.895 (excellent), and all coefficients for LKH, PP, CNVHL, ĐG, and KT are positive, indicating that these variables have a positive impact on the development of **NLTH** (self-learning ability). The **Adjusted R Square** value is **0.799**, meaning that **79.9%** of the variance in the dependent variable is explained by the five independent factors. This confirms that the linear regression model fits the sample dataset at a **79.9%** level.

In **Table 14**, the significance value (Sig.) of the **F-test** is **< 0.01**, indicating that the regression model is statistically significant at a **99% confidence level**.

In **Table 15**, examining the statistical significance column (Sig.), all variables have **Sig. < 0.01**, confirming that all factors significantly influence students' self-learning ability with **99% confidence**. Additionally, all **Variance Inflation Factor (VIF)** values are below **3**, indicating no multicollinearity (Hair et al., 2019).

The standardized regression equation is formulated as follows:

F(NLTH)= .292 * LKH+ .174 * PP+ .116 * CNVHL+ .229 * ĐG+ .304 * KT

Where **F** represents the impact level of independent variables on students' self-learning development. Specifically:

- **LKH** (Study Planning and Flexible Implementation): **29.2%** impact.
- **PP** (Selection and Application of Appropriate Learning Methods and Techniques): **17.4%** impact.
- **CNVHL** (Searching, Synthesizing, and Effectively Using Learning Resources and Information Technology for Self-Improvement): **11.6%** impact.
- **ĐG** (Self-Evaluation to Identify Strengths, Weaknesses, and Self-Improvement): **22.9%** impact.
- **KT** (Persistence in Self-Learning, Especially When Facing Difficulties and Challenges): **30.4%** impact.

These criteria can also be used to assess students' self-learning ability in other learning models and methodologies.

5. Discussion and Interpretation of Findings

Research on the flipped classroom (FC) model in Vietnam indicates that its implementation is becoming increasingly prevalent, aligning with broader educational reform efforts in the context of digital transformation. While previous studies have primarily examined the impact of the FC model on student learning outcomes (Nguyen & Tran, 2023), the present study extends this focus by not only reaffirming the model's feasibility but also proposing five key criteria for evaluating middle school students' self-learning competency (SLC). Among these criteria, perseverance emerged as the most influential factor (30.4%) in SLC development within the FC model, underscoring the critical role of emotional resilience and intrinsic motivation—dimensions that have received limited attention in prior research.

This finding can be contextualized within Vietnam's educational landscape, where traditional teaching methods emphasize rote memorization and passive knowledge acquisition. The transition to the FC model demands that students not only engage with lesson content before attending class but also cultivate perseverance to adapt to a more autonomous and interactive learning approach. This shift is particularly significant in mathematics education, a discipline that requires logical reasoning, problem-solving skills, and sustained effort in mastering complex concepts.

To ensure the effectiveness and scalability of the FC model within the framework of digital transformation, targeted interventions are required to enhance educational accessibility. These interventions should include the provision of adequate technological infrastructure, the development of user-friendly digital learning resources, and the continuous professional development of educators through specialized training programs. Furthermore, policy support and institutional engagement are essential for fostering an environment in which both teachers and students can effectively navigate the challenges and opportunities presented by the FC model.

6. Conclusion and Recommendations

Amid the rapid advancement of digital transformation, learners now have access to more flexible and dynamic educational environments than ever before. To fully harness the potential of digitalization in education, particularly in supporting the FC model, strategic initiatives must be undertaken. Educational institutions should prioritize investments in technological infrastructure, the creation of high-quality digital learning materials, and the professional development of teachers to facilitate the successful implementation of innovative teaching methodologies.

Beyond instructional benefits, digital transformation also enhances the processes of assessment and self-assessment, providing learners with opportunities for continuous feedback and personalized learning experiences. In this context, perseverance and resilience should be recognized as fundamental attributes for students to succeed in FC-based learning environments. Digital tools, by enabling real-time progress tracking and adaptive learning pathways, play a crucial role in improving learning efficiency and fostering student autonomy. Cultivating self-learning habits is particularly vital, as it forms the foundation for sustainable education and prepares learners to adapt to the rapidly evolving demands of the modern world.

In conclusion, optimizing the FC model in the digital transformation era requires close collaboration among key stakeholders, including schools, educators, students, and policymakers. The integration of technology with evidence-based pedagogical approaches not only enhances teaching and learning quality but also cultivates independent thinking, problem-solving abilities, and lifelong learning skills. These competencies are essential for building a resilient, future-oriented education system that is both adaptable and sustainable in an increasingly complex global landscape.

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