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A Novice Teacher's Self-Development Journey: Adapting Flipped Classroom Learning with AI Integration for Modern Classroom

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ABSTRACT

This study investigates novice teachers' professional development as they navigate the integration of Flipped Classroom (FC) methodologies and Artificial Intelligence (AI) tools in contemporary educational settings. The primary objective was to examine how these technologies influence early career educators' teaching competencies and professional growth. Employing a mixed-methods design, the research commenced with qualitative interviews and classroom observations to uncover the challenges, strategies, and experiences associated with implementing FC and AI. This was complemented by a quantitative survey that assessed the effectiveness of the integration. Thirty novice teachers participated in the study. AI tools contributed to more personalized learning experiences, while the FC approach facilitated increased student interaction and engagement. Nonetheless, participants reported encountering technical issues and insufficient training. This study underscores the necessity of ongoing professional development and institutional support to enable novice teachers to utilize AI and FC approaches effectively. Overall, the results suggest that novice teachers can enhance their instructional competencies with adequate resources and mentorship, and foster more dynamic, student-centered learning environments in the digital era. This study uniquely explores how novice teachers integrate FC methods and AI tools. Employing a mixed-methods approach provides a nuanced understanding of the pedagogical benefits, challenges, and developmental needs associated with this dual integration. The findings highlight the critical role of institutional support and targeted professional development in empowering early career educators to create student-centered, technology-enhanced learning environments, thereby bridging a significant gap in the current teacher education and edtech literature.

Keywords: Novice Teachers, Flipped Classroom (FC), Artificial Intelligence (AI), Professional Development, Teaching Competencies, Student-Centered Learning.

INTRODUCTION

The FC pedagogy represents a foundational shift from teacher-centered delivery to student-initiated engagement, where learners explore instructional content outside of class and use in-class time for discussion and problem-solving (Mishall et al., 2025). This model reimagines traditional education by enabling students to engage with instructional content out of class, reserving classroom time for collaborative higher-order thinking activities (Khatoon, 2024; Mengesha et al., 2024; Sousa et al., 2024). It represents a paradigm shift in which passive content consumption replaces active inquiry-based learning, fostering deeper comprehension and retention (Nichat et al.,

2023). Empirical research supports this model's efficacy in enhancing student engagement, promoting learner autonomy, and improving academic outcomes (Khatoon, 2024; Oudbier et al., 2022; Ribeiro et al., 2025). Additional studies have highlighted its utility across disciplines, noting benefits such as increased classroom interaction and student satisfaction (Baig & Yadegaridehkordi, 2023; Strelan et al., 2020). However, persistent barriers include unequal access to digital tools, insufficient teacher training, and resistance to pedagogical change (Satparam & Apps, 2022; Zulaikhah et al., 2024).

Despite the low-to-medium effect sizes reported in some meta-analyses, instructional design characteristics such as formative assessments and pre-class activities, and continuous professional development play a crucial role in the model's success (Wagner, 2024; Zulaikhah et al., 2024). In the Chinese context, the FC has shown the potential to transform education by promoting dynamic and personalized learning environments, although this requires a paradigm shift in teaching and learning practices (Chen, 2024; Sun et al., 2025). Broader international studies have also affirmed the model's capacity to support differentiated instruction, particularly when complemented by digital tools and reflective teaching strategies (Chavez, 2025; Sara, 2023). Overall, the FC model holds promise for creating more inclusive and future-ready educational settings, provided that existing barriers are addressed through strategic planning and investment in technology and educational development (Khatoon, 2024; Sousa et al., 2024).

At the same time, AI redefines educational paradigms through its capacity to deliver adaptive student-centered learning and streamline institutional processes (Manprisio et al., 2024). Central to this transformation are tools such as Intelligent Tutoring Systems (ITS), AI-driven chatbots, and educational data-mining platforms, which provide customized learning trajectories by continuously analyzing student behavior and performance metrics (Kabudi et al., 2021; Kodir, 2025; López-Meneses et al., 2025). In addition to automating administrative functions such as grading and feedback, AI supports progressive pedagogical approaches such as project-based learning and gamification, fostering engagement and deeper learning outcomes (D'Ambrosio, 2025; Kassenkhan et al., 2025). However, the integration of AI into educational systems is not concerning. Key challenges include maintaining data privacy, upholding academic integrity, and mitigating the risk of diminishing critical thinking owing to over-reliance on automated systems (Choi et al., 2025; Patrizi et al., 2025). Investing in robust digital infrastructure, designing comprehensive teacher-training programs, and implementing ethical AI frameworks is imperative to fully harness AI's potential of AI in education. These measures are crucial for ensuring equity, preventing algorithmic bias, and cultivating inclusive learner-centric environments (Kodir, 2025; López-Meneses et al., 2025; Metwalli, 2025).

Therefore, AI significantly augments the FC model by enhancing personalization, boosting student engagement, and nurturing creativity (Ifraheem et al., 2024). The integration of generative AI tools such as ChatGPT has demonstrated measurable improvements in students' creative writing and engagement, with learners in AI-enhanced environments reporting more favorable experiences and outcomes than those in traditional settings (Khuibut, 2024) .Despite these advantages, several challenges remain. Effective integration requires sufficient technological infrastructure, ongoing teacher training, and ethical safeguards to address concerns related to data privacy and equitable access (López-Villanueva et al., 2024; Suvendu & S., 2024). Ultimately, the AI-enhanced FC paradigm offers a forward-looking educational strategy that empowers students and supports teachers in delivering high-impact learner-centered instruction (Bui, 2024; López-Villanueva et al., 2024).

Accordingly, the journey of a novice teacher integrating AI into FC environment encapsulates both the promise and the complexity of educational innovation. AI enables personalized learning and operational efficiencies, but lacks teachers' relational and ethical depth, such as socio-emotional engagement and moral guidance (Septiani & Ramadani, 2025; Wang et al., 2024). Building AI literacy through sustained professional development is essential for novice educators to harness these technologies meaningfully (Holmes, 2019; Valenzuela, 2025). In FC settings, AI contributes significantly to cultivating 21st-century competencies, including critical thinking, collaboration, creativity, and communication, through adaptive content and formative feedback loops (Bui, 2024; Islami et al., 2024). However, the real-world integration of tools such as Magic School AI demands new technical proficiencies, such as prompt engineering and contextual adaptation of AI-generated content, underscoring the need for targeted instructional support (Park & Choo, 2024; Setyaningsih et al., 2024). While studies have shown that foreign language teachers are open to AI for differentiated instruction, broader pedagogical frameworks for integrating AI into FC models remain underexplored, especially in novice teacher training (Christina & Panagiotidis, 2024; Holmes, 2019). Therefore, this study seeks to bridge this gap by examining how novice teachers evolve professionally in AI-enhanced flipped environments.

This research aims to address the following questions:

(1) How does a novice teacher develop self-directed learning while adapting FC with AI integration?

(2) How does AI integration in FC learning impact novice teachers' teaching competencies?

The conceptual framework of this study (shown in Figure 1) is grounded in Self-Directed Learning (SDL) theory and the Technological Pedagogical Content Knowledge (TPACK) model, which positions novice teachers at the center of pedagogical innovation. This framework illustrates the interplay of inputs, processes, and outcomes in

the professional development of novice teachers adopting an AI-enhanced FC pedagogy. Inputs include institutional conditions and teachers' initial readiness, feeding into Self-Directed Learning that fosters independent engagement with AI technologies. Processes are driven by the implementation of AI Tools, which are adaptively used to personalize instruction and support instructional design. These tools are also shaped by, and contribute to, teachers' TPACK, reflecting the integration of technological, pedagogical, and content knowledge. AI tools and SDL collectively inform the application of FC Pedagogy, which serves as an instructional platform for implementing student-centered learning. The outcomes focus on evolving teaching competence and professional identity, ultimately enhancing instructional effectiveness and learner engagement. This integrated model highlights the cyclical and systemic nature of AI integration in novice teacher development, emphasizing the importance of feedback loops, infrastructure and pedagogical alignment.

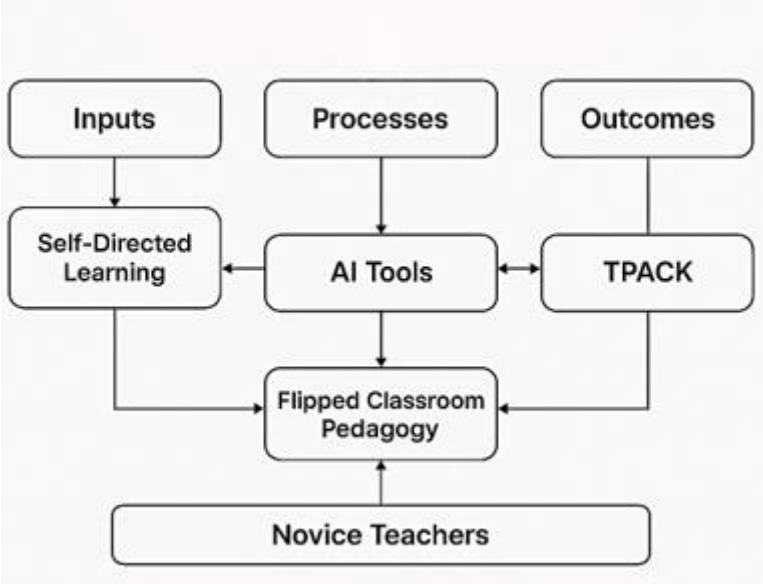

Figure 1. Conceptual Framework.

METHOD

Research Design

This study employed a mixed-methods design to examine novice teachers' professional development trajectories in integrating AI into FC pedagogy. The first phase used a qualitative approach to explore novice teachers' initial readiness, perceptions, and self-directed learning behaviors through thematic analysis of open-ended responses. The second phase employed a sequential exploratory design, combining qualitative insights with quantitative assessments and performance data to triangulate and validate findings.

Participants

This study involved 30 student teachers enrolled in a public university in Thailand. Participants were selected through **purposeful random sampling**, a strategy that ensured alignment with the study's objectives, while incorporating variability within the novice teacher population. All participants had completed at least one prior teaching internship as part of a practicum course, providing them with foundational classroom experiences essential for exploring AI integration in pedagogical settings.

Eligibility criteria included:

i. Individuals aged between 19 and 25 years of any gender.
ii. Completion of a school-based teaching internship.
iii. Voluntary consent to participate in a four-week intervention study.

The research protocol was approved by the university ethics review board (approval no. WUEC-25-050-01). Informed consent was obtained from all participants, and stringent measures were employed to protect their anonymity and data confidentiality. Participants were fully informed of their right to withdraw from the study at any stage without penalties.

Data Collection and Analysis Methods at Different Stages

Research Objective 1: Qualitative Methodology

This stage employed a phenomenological research approach to explore novice teachers' readiness to integrate AI into FC instruction. This methodology is particularly well suited to investigating lived experiences, offering a nuanced understanding of participants' perceptions, challenges, and motivations, as they navigate AI-enhanced pedagogy in authentic educational settings.

Data Collection

Data were collected via an online questionnaire designed to elicit rich, reflective responses regarding participants' experiences with AI in the context of flipped learning. The survey instrument consisted of both closed- and open-ended items and was administered through Google Forms. Participants were given a week to complete the survey at their convenience. An online survey modality was chosen for its ability to support asynchronous participation, thereby reducing respondent pressure and allowing thoughtful reflection. Furthermore, the anonymity of digital responses is expected to promote greater candor, particularly in disclosing uncertainties or challenges in technology adoption (Campbell et al., 2022).

Data Analysis

All survey responses were initially provided in Thai and were subsequently translated into English by both researchers to ensure trust worthiness and semantic accuracy. The translated data were analyzed following the thematic analysis framework outlined by Saldaña (2021). This multi-step process involves the following steps.

1. Familiarization through repeated reading of the data;
2. Generation of initial codes using inductive reasoning;
3. Development of broader themes that capture participants' engagement with AI and self-directed learning;
4. Review and refinement of themes to ensure analytical coherence and eliminate redundancy.

The analysis was conducted manually (by hand) to enable more immersive and reflective interaction with the data. Hand-coding provides the flexibility to adapt coding strategies in response to emerging insights, which is essential in phenomenological research to preserve the complexity and authenticity of human experiences (Mihas, 2019). This analytical process facilitated a comprehensive understanding of the cognitive, emotional, and contextual factors that influence novice teachers' readiness to employ AI within flipped pedagogical frameworks.

Research Objective 2: Mixed Methods Approach

A **sequential exploratory mixed-methods approach** was employed to obtain a holistic understanding of novice teachers' readiness and competencies in integrating AI into FC teaching. This design allowed for qualitative exploration of participants' lived experiences, followed by quantitative validation of the findings through pattern measurement and statistical interpretation. This methodology aligns with Gogo and Musonda (2022), who emphasized that sequential exploratory designs enable researchers to develop in-depth insights during the qualitative phase, which then inform the structure and focus of the subsequent quantitative phase. The integration of both data strands enhances the depth, breadth, and validity of the educational research.

Qualitative Phase

This phase adopted a **qualitative case study design** to examine novice teachers' contextualized experiences and practices, as they implemented AI tools within flipped instructional models. This approach provides rich, context-sensitive insights into pedagogical adaptations and perceived readiness.

Data Collection

Data were gathered via an open- and closed-ended survey administered through Google Forms. The survey was part of Research Objective 1 and aimed to capture participants' experiences and attitudes toward AI-enhanced flipped teaching. Supplementary data were also derived from a documentary review of the relevant literature, including textbooks, reports, and empirical research. These sources were used to inform the development of a conceptual model outlining the components of novice teachers' readiness for AI integration in FC.

Data Analysis

A thematic analysis of survey responses was supported by a qualitative assessment rubric explicitly developed for evaluating the Novice Teacher Readiness Model for Using AI in FC Teaching. The codes and themes were identified inductively and refined to produce a robust and coherent interpretive framework.

Quantitative Phase

Following qualitative analysis, a quantitative survey was conducted with the same cohort of participants. This phase aimed to statistically assess readiness patterns, validate the thematic constructs identified earlier, and examine the practical applicability of the proposed readiness model. The survey instrument was structured based on the dimensions of readiness that emerged in the qualitative phase.

Data Collection

The participants engaged in a four-week structured training program in a computer laboratory setting. The training followed a predefined course structure titled *"Integrating AI in FC to Enhance Teaching Competencies of Novice Teachers"*. This intervention was designed to develop foundational skills for AI tool usage, instructional planning, and self-assessment. The training outcomes informed the design and interpretation of the quantitative readiness assessment.

Table 1 presents the structured training framework designed to build the competencies of novice teachers in integrating AI into FC pedagogy. The course spans five modules, each focusing on key instructional areas, including foundational knowledge, AI-driven material development, classroom management, teacher self-development, and AI-integrated lesson planning.

Each module incorporates specific AI tools (e.g., ChatGPT, Synthesia AI, EdPuzzle AI) aligned with targeted success indicators. For instance, teachers were trained to design instructional materials using Canva AI and Quizizz and to analyze classroom data using EdPuzzle AI and Grammarly AI. The curriculum is scaffolded to progressively deepen teacher engagement with AI from basic conceptual understanding to advanced application in lesson design and formative assessment. This structured progression supports the development of Technological Pedagogical Content Knowledge (TPACK) and fosters self-directed learning, reinforcing the study's aim of empowering novice teachers with the skills necessary for contemporary, tech-integrated teaching contexts.

Table 1. Course Structure Overview.

Module	Content	AI Tools Used	Success Indicators
1. AI & FC Basics	Basic AI & FC concepts	ChatGPT, Canva AI	Teachers understand AI & FC principles
2. AI in Teaching Materials	Creating videos, quizzes, infographics	Synthesia AI, Canva AI, Quizizz	Teachers create teaching materials with AI
3. AI in Classroom Management	Analysing learning outcomes, tracking behavior	EdPuzzle AI, Grammarly AI	Teachers analyse student data using AI
4. AI for Teacher Development	Receiving feedback on teaching, self-analysis	VEO AI, SpeechCoach AI	Teachers improve teaching with AI feedback
5. Designing FC with AI	Lesson Plan design, Assessment integration	Lesson Planner AI, Google Sheets AI	Teachers design AI-integrated lessons

Data Analysis

In this stage, SPSS26.0 was used to analyze the quantitative data to ensure the appropriateness of the inferential statistics.

FINDINGS

To Explore How Novice Teachers Are Prepared to Use AI Effectively in FC Teaching (RO1)

Table 2 summarizes the demographic and educational backgrounds of the study participants, which consisted of 30 student teachers aged between 19 and 25 years, with a balanced representation of male and female participants. All respondents were enrolled in a teacher education program and had completed at least one school-based teaching internship, qualifying them as novice teachers.

Table 2. General information of the respondent (n=30)

General information	Frequency	Valid Percent
Gender		
Male	16	53.3
Female	14	46.7
Other (Please specify)	-	-
Teaching Experience		
Less than 1 year	25	83.3
1-3 years	5	16.7
4-5 years	-	-
More than 5 years	-	-
Teaching grade		
Primary	9	30.0
Secondary	21	70.0
Higher education	-	-
Other (Please specify)	-	-
How much experience do you have using FC		

None	12	40.0
A little (I've tried it some times)	15	50.0
A moderate amount (I use it in some subjects)	3	10.0
A lot (I use it regularly)	-	-
Have you ever used AI in teaching?		
Never	-	-
Used it a little	17	56.7
Used it sometimes	13	43.3
Used it regularly	-	-

As shown in Table 3, novice teachers implementing AI in the FC model reported high levels of self-perceived readiness and growth. They demonstrated strong self-directed learning behaviors, positively engaged with AI tools despite challenges, and experienced pedagogical gains, including enhanced teaching effectiveness, role adjustment, and increased tech confidence. These findings suggest a high adaptability among novice teachers, supported by institutional resources, and point to the model's scalability in teacher education.

Table 3. Quantitative Results: Self-development process in using FC integrated with AI (n=30).

	(X̄)	**(SD)**	**Level of Self-Development**
Learning and Self-Development	**3.66**	**.78**	High
1. I researched information about FC on my own before using it.	3.45	.90	High
2. I researched AI for teaching from various sources, such as online courses, books, or video tutorials.	3.92	0.78	High
3. I experimented with AI in teaching to see the results and develop further.	3.66	0.99	High
Challenges and Obstacles	**3.87**	**0.85**	High
5. I found that using AI in teaching was complicated and time-consuming to learn.	3.86	1.06	High
6. I have received support from my school/university in using AI and FC.	3.77	0.84	High
Outcomes of Personal Development	**3.73**	**0.80**	High
7. I feel that using FC with AI makes me teach more effectively.	3.78	1.00	High
8. I can adjust my role to be more of a coach or assistant than a lecturer.	3.70	0.99	High
9. I have more confidence in using technology in teaching.	3.72	0.99	High

To Explore How AI Integration in FC Learning Impacts Novice Teachers' Teaching Competencies (RO2)

To explore how AI integration in FC learning impacts the teaching competencies of novice teachers, we have implemented a course structure overview by using the results from RO1 to analyze the needs of this course, and their scores in each area were as follows:

Module 1: Basic Knowledge of AI and FC

The first module of the training program was designed to build foundational knowledge in both AI and FC pedagogy. This module introduced participants to the core principles of AI, its potential applications in educational contexts, and the pedagogical rationale for using the FC model. Emphasis was placed on understanding the benefits of AI in supporting differentiated instruction, increasing student engagement, and enhancing instructional design. Participants were also introduced to a curated set of AI technologies suitable for classroom use and strategies for integrating these tools into flipped instructional designs. A practical component of the module is lesson planning with AI support. Success indicators for this module include (1) the ability to accurately articulate the foundational concepts of AI and FC pedagogy, and (2) the ability to identify and justify the selection of appropriate AI tools for specific teaching contexts.

A pre-test and post-test were administered to assess learning outcomes, each comprising 15 multiple-choice items (maximum score: 15 points). The performance criteria are defined as follows.

i. 13–15 points: High proficiency in conceptual understanding and tool application.
ii. 8–12 points: Moderate understanding with partial competency in selecting AI tools.
iii. Below eight points: Indicates a need for further development in both AI and FC foundational knowledge.

As indicated in Table 4, paired samples *t*-test results indicated a significant improvement in novice teachers' understanding of AI and FC pedagogy after Module 1 (mean difference = 3.80, $p < .001$). The narrow confidence

interval and low standard error confirm the consistency and practical significance of this gain, supporting the effectiveness of Module 1 in building foundational knowledge. These assessment results informed individualized instructional support and validated readiness benchmarks for subsequent modules.

Table 4. Learning outcomes before and after Module 1 learning-Paired Samples t-test

	Paired Differences							
	Mean	**Std. Deviation**	**Std.Error Mean**	**95%Cofidence Interval of the Difference**		**t**	**df**	**Sig.(2-tailed)**
				Lower	Upper			
Pair 1 Posttest-pretest	3.800	1.243	.227	3.336	4.264	16.746	29	0.000

Module 2: Using AI to Create Teaching Materials for FC

This module covers the use of AI to create teaching materials for FC and focuses on how to use AI to create pre-class learning materials, such as videos and infographics, as well as how to design automated quizzes and learning activities using AI. The success indicators were:(1) the teacher's ability to create pre-class learning materials using AI, and (2) the teacher's ability to design automated quizzes.

The assessment in this section was based on a Workshop and a Project. In the workshop, the teacher would design a teaching video using AI, and in the project, the teacher would create a set of tests for students.

The results in Table 5 show that, novice teachers demonstrated moderate-to-high competency in AI-supported instructional design (overall M = 3.31, SD = 0.59). They excelled in content accuracy and creativity but showed weaker performance in student engagement and technical quality. These results highlight the need for further support in designing AI-integrated materials that are both pedagogically sound and engaging.

Table 5. Using AI to Design Instructional Materials for FC

Assessment Criteria	**Full Score**	**(X)**	**(SD)**
Creativity and Innovation	5	3.50	0.73
Content Accuracy	7	4.70	0.97
Clarity and Organization	5	3.27	0.78
Technical Quality	5	3.13	0.90
Student Engagement	3	1.97	0.56
Total	25	3.31	0.59

Module 3: Using AI for Classroom Management in FC

This module focuses on applying AI to support formative assessment through student progress monitoring and personalized feedback. It aims to equip novice teachers with the skills to analyze student learning behaviors using AI-generated data and design responsive systems for tracking academic performance. Two key success indicators guide the assessment: (1) the teacher's ability to interpret learning analytics using AI tools and (2) the ability to provide adaptive, individualized feedback based on these insights. The assessment was conducted through a case study and a practical application exercise.

In the case study, the participants analyzed simulated student data using AI to identify patterns in engagement and achievement. The practice exercise required teachers to design and demonstrate an AI-supported tracking system to monitor student performance. Performance was evaluated based on the accuracy of data interpretation and the instructional relevance of the tracking system. This module reflects the growing importance of data-informed pedagogy, and highlights how AI can enhance teachers' diagnostic and feedback capabilities in technology-integrated classrooms.

Table 6. Evaluation of AI-Based Student Monitoring and Feedback Competency

Assessment Criteria	Full Score	(X)	(SD)
System Outcome Tracking Design	7	5.97	0.72
Appropriateness of AI Tool Selection	5	4.47	0.51
Effective System Usage	4	2.77	0.43
Automatic Feedback Provision	4	1.63	0.49
Total	20	3.17	0.27

As evidenced by Table 6, novice teachers showed moderate overall proficiency in implementing AI-based systems for monitoring and feedback (M = 3.17, SD = 0.27). While they performed well in AI tool selection and system outcome tracking design, lower scores in practical application, especially in automatic feedback, indicates a need for further training in using AI for formative assessment and personalized feedback.

Module 4: Using AI to Develop the Competencies of Novice Teachers

This module investigates the role of AI in supporting teacher self-evaluation and professional growth, with a focus on enhancing instructional design and communication competencies. It introduced participants to AI-based tools capable of analyzing teaching performance, generating targeted feedback, and identifying areas for pedagogical improvement. The module's success indicators include (1) the teacher's ability to use AI to critically assess their instructional strengths and weaknesses, and (2) the application of AI-generated feedback to iteratively refine teaching practices.

The assessment was conducted through a structured self-assessment activity, in conjunction with AI feedback analysis. Participants were evaluated on their capacity to interpret diagnostic insights from AI and translate them into actionable strategies for professional development. Scoring reflects the degree to which teachers demonstrate reflective engagement with AI feedback, and the extent to which they incorporate these insights into evidence-based instructional adjustments. This module aims to cultivate a mindset of continuous self-improvement by leveraging AI as a formative tool for reflective teaching.

Based on the data in Table 7, novice teachers demonstrated high overall proficiency in using AI for reflective practice (overall M = 4.77, SD = 0.34), particularly in self-analysis and using AI feedback to improve teaching. However, lower scores in improving communication skills and teaching design indicate the need for additional support in translating feedback into pedagogical refinement.

Table 7. Evaluation of novice teachers' ability to utilize AI

Assessment Criteria	Full Score	(X)	(SD)
Self-Analysis of Strengths and Weaknesses	8	5.70	0.95
Using AI Feedback to Improve Teaching	8	5.90	0.61
Improving Communication Skills and Teaching Design	4	2.70	0.47
Total	20	4.77	0.34

Module 5: Designing a FC Lesson Plan Using AI

This module covers lesson plan design using AI, the application of AI in assessment and evaluation, and the analysis of student learning outcomes using AI. The success indicators include (1) teachers' ability to design lesson plans using AI, and (2) their ability to assess student learning with AI effectively. The evaluation is conducted through workshops and projects, where teachers design lesson plans using AI in workshops and utilize AI for student assessment in projects. Scores are based on the teachers' ability to create effective lesson plans and appropriately apply AI for learning outcome evaluation.

As presented in Table 8, novice teachers exhibited moderate-to-high competency in AI-integrated lesson planning (M = 3.76, SD = 0.43), with their strongest performance in lesson completeness and effectively aligning AI with the FC model. However, lower scores in the appropriateness of activities and evaluation, as well as in creativity and innovation, indicate a need for targeted support to enhance instructional creativity and integrate more effective assessment strategies.

Table 8. Assessment of AI-Integrated Lesson Plan Design.

Assessment Criteria	**Full Score**	**(X)**	**(SD)**
Completeness of the Lesson Plan	6	4.83	0.70
Connection Between AI and FC	6	4.37	0.72
Creativity and Innovation	4	3.30	0.65
Appropriateness of Activities and Evaluation	4	2.53	0.73
Total	20	3.76	0.43

The course evaluation employed a tiered rubric to classify participants into four levels of AI integration proficiency within FC pedagogy. Scores of 80–100 were deemed "Excellent," reflecting strong conceptual and practical competence; 60–79 as "Good," indicating a solid foundation with room for improvement; 40–59 as "Moderate," showing basic understanding but limited application; and below 40 as "Needs Improvement," highlighting minimal proficiency and the need for substantial support.

As indicated in Table 9, all participants were rated as either "Excellent" (46.7%) or "Good" (53.3%) in applying AI within the FC model, indicating strong overall proficiency. The absence of lower-tier scores highlights the training program's effectiveness and its potential for broader application in teacher development.

Table 9. Summative Evaluation of AI-Flipped Classroom Training Outcomes

No	Total Score	Evaluation Level
1	83	Excellent
2	74	Good
3	84	Excellent
4	74	Good
5	72	Good
6	73	Good
7	84	Excellent
8	80	Excellent
9	82	Excellent
10	73	Good
11	72	Good
12	82	Excellent
13	75	Good
14	76	Good
15	81	Excellent
16	82	Excellent
17	81	Excellent
18	80	Excellent
19	79	Good
20	74	Good
21	78	Good
22	76	Good
23	81	Good
24	73	Good
25	79	Good
26	82	Excellent
27	81	Excellent
28	78	Good
29	82	Excellent
30	80	Excellent

DISCUSSION

Novice Teachers' Learning Experiences

Integrating AI into FC pedagogies presents opportunities and challenges for novice teachers as they transition from traditional teacher-centered instruction to more student-driven approaches. This shift necessitates the acquisition of new technological competencies along with pedagogical transformation. Consistent with prior research (Khatoon, 2024; Sousa et al., 2024), this study found that, while novice teachers initially experienced uncertainty and apprehension, the use of AI tools, particularly those providing personalized feedback and adaptive content delivery, significantly enhanced their instructional confidence and learner engagement (Khuibut, 2024; Suvendu & S., 2024). However, successful integration is frequently hindered by infrastructural limitations, inadequate training, and concerns about data privacy (López-Villanueva et al., 2024; Suvendu & S., 2024). When provided with appropriate institutional support and scaffolded learning opportunities, novice teachers demonstrated notable growth in digital literacy and self-efficacy (Niño & Casal, 2024; Okraj & Lenihan, 2024; Wahab et al., 2024).

Pedagogical Impact of AI-Flipped Learning

These findings underscore the transformative potential of combining AI and FC models to enrich both teaching practices and student learning outcomes. AI-enabled platforms such as Intelligent Tutoring Systems and adaptive learning tools facilitate differentiated instruction, allowing novice teachers to tailor learning pathways to diverse student needs (Suvendu & S., 2024). The FC structure promotes self-regulated learning, with pre-class exposure to instructional content freeing classroom time for collaborative and higher-order thinking tasks (Khatoon, 2024; Sousa et al., 2024). This pedagogical reconfiguration redefined the role of teachers as facilitators,

shifting their focus toward guiding inquiry and providing real-time feedback, an evolution that aligns with contemporary views on learner-centered education (Bui, 2024; López-Villanueva et al., 2024).

Problems and Challenges Encountered

Despite these advantages, novice teachers frequently encounter barriers to its implementation. Technical challenges, such as unreliable software performance and the limited user-friendliness of AI interfaces, have emerged as significant impediments (Suvendu & S., 2024). Additionally, disparities in access to digital infrastructure and instructional technologies, particularly in under-resourced educational settings, have constrained the full realization of AI's benefits (Ribeiro et al., 2025). The lack of structured training on digital pedagogies further limits teachers' capacity to fully integrate AI into FC lesson planning and delivery (Wagner, 2024). These challenges highlight the necessity for systemic interventions to bridge the digital divide and support novice teachers in overcoming the initial barriers to adoption.

Development of Personal and Professional Competencies

A central finding of this study is the emergence of Self-Directed Learning (SDL) as a core mechanism enabling novice teachers to acquire and refine their digital teaching skills. Teachers reported engaging in self-directed learning, experimenting with AI tools, and reflecting on feedback to inform continuous improvement behaviors that align with SDL principles (Gu, 2024). The presence of institutional support, such as mentorship, access to learning resources, and professional learning communities, plays a critical role in fostering confidence and adaptability among novice teachers (Okraj & Lenihan, 2024; Wahab et al., 2024). These findings suggest that effective teacher development in AI-FC integration is a product of both individual initiatives and contextual support structures.

Role of Institutional Support

Institutional support has emerged as a decisive factor in facilitating the successful integration of AI and FC methodologies by novice teachers. Structured training programs, ongoing technical assistance, and access to digital tools have been cited as key enablers of professional growth (Okraj & Lenihan, 2024). Moreover, institutions that foster collaborative environments through peer sharing, coaching, and reflective practice enable novice teachers to accelerate their learning trajectories and overcome the typical inertia associated with educational technology adoption (Suvendu & S., 2024; Wahab et al., 2024). Thus, organizational investment in technological infrastructure and teacher capacity building is indispensable for scaling AI-enhanced pedagogical innovation.

Recommendations for Practice and Policy

Institutions should implement sustained context-responsive professional development programs to strengthen AI and FC integration in teacher education. These should include technical skill building, pedagogical modeling, and hands-on opportunities to explore tools, such as Intelligent Tutoring Systems, interactive content creators, and AI-supported assessment platforms (Sousa et al., 2024; Suvendu & S., 2024). Creating mentorship networks and platforms for novice-expert collaboration can further support iterative learning and innovation (Wahab et al., 2024). Finally, policies should prioritize equitable access to digital resources and ensure that ethical considerations such as data privacy and algorithmic fairness are addressed within the design of educational AI systems(Gu, 2024). These multi-layered supports are vital for enabling novice teachers to navigate the complex demands of AI integrated, learner-centered instruction.

CONCLUSION

This study examines the self-development trajectories of novice teachers integrating AI and FC pedagogies in contemporary instructional settings. These findings underscore that the synergistic use of AI and FC significantly enhances novice teachers' instructional competencies, particularly in content differentiation, learner engagement, and pedagogical adaptability. Despite initial barriers, including technological unfamiliarity, instructional redesign demands, and infrastructural limitations, participants demonstrated marked improvements in digital fluency and pedagogical confidence when supported by targeted institutional training and resources.

AI integration was particularly effective in facilitating personalized learning experiences through adaptive feedback and performance tracking, while the FC model promoted active inquiry-based learning environments. These pedagogical shifts redefined the role of novice teachers, positioning them as facilitators of learner-centered education. Institutional support has emerged as a central enabler, with ongoing professional development, technical access, and collaborative learning spaces, proving essential for successful implementation.

To sustain and scale these benefits, educational institutions must invest in continuous practice-oriented training that fosters technological proficiency and pedagogical innovation. Emphasizing Self-Directed Learning (SDL) as

a developmental strategy empowers novice teachers to take ownership of their professional growth by setting goals, accessing digital resources, and engaging in reflective practices. Such an ecosystem not only allows teachers to navigate emerging educational technologies, but also contributes to long-term instructional excellence and improves student learning outcomes.

Ethical Compliance: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Data Access Statement: Research data supporting this publication are available from the corresponding author on reasonable request.

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