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A TEACHER PROFESSIONAL DEVELOPMENT MODEL FOR EFFECTIVE INTEGRATION OF QUALITY EDUCATION USING TECHNOLOGY BASED ON THE SUSTAINABLE DEVELOPMENT GOALS IN THAILAND

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ABSTRACT

This study developed and implemented a sustainable teacher professional development (TPD) model in Thailand, aligned with the quality education of Sustainable Development Goals (SDGs), to enhance the effective integration of educational technology. The study aimed to: (1) investigate the current situation, challenges, and professional development needs of teachers; (2) develop a sustainable teacher professional development (TPD) model and (3) implement and evaluate the effectiveness of the proposed TPD model in enhancing teachers' digital and pedagogical competencies. A research and development approach was employed, including in-depth interviews, focus group discussions, brainstorming sessions, and hands-on classroom implementation with observation of resulting teaching practices across diverse school contexts. Findings revealed that teachers faced limited digital skills, inconsistent integration of sustainability content, and a need for continuous collaborative learning. The developed framework comprised three interrelated models: Digital Skills Enhancement, SDG-based Pedagogical, and Professional Learning Communities (PLCs). Implementation demonstrated improvements in teachers' technology use, curriculum design, sustainability-oriented teaching, and collaborative professional growth. This study provides a theoretically informed and practical framework for sustainable TPD, supporting SDG 4 (Quality Education) and advancing SDGs 8, 12, 13, and 17, contributing both to research and practice in educational technology.

KEYWORDS: Teacher Professional Development, Educational Technology Integration, Sustainable Education, Quality Education

1. INTRODUCTION

In the 21st century, education worldwide is increasingly shaped by the integration of digital technologies, fundamentally changing how teachers teach, students learn, and schools operate (Ertmer & Ottenbreit-Leftwich, 2010; OECD, 2021). In Thailand, the rapid adoption of online learning platforms, digital content, and virtual classrooms accelerated by the COVID-19 pandemic has highlighted both opportunities and challenges in teacher professional development (TPD) (Ertmer & Ottenbreit-Leftwich, 2010). Teachers must not only master digital tools but also redesign pedagogy for blended learning and integrate sustainability principles into their teaching practices (König et al., 2020).

Despite numerous PD initiatives, Thai teachers face limited access to continuous, high-quality programs. Most offerings are short-term workshops lacking follow-up, mentoring, or practical classroom application, and are often misaligned with national or global educational goals. Geographic and institutional disparities exacerbate these challenges: urban schools generally have better digital infrastructure, while rural and remote schools encounter limited resources, low connectivity, and fewer opportunities for collaborative learning (OECD, 2021). School type and regional policies further shape the professional development needs of teachers.

These gaps underscore the need for a sustainable teacher professional development model that strengthens digital competencies, fosters continuous collaborative learning, and aligns with the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth) (UNESCO, 2021). Such a model should emphasize lifelong learning, structured context specific programs, and professional learning communities (PLCs) that enable mentoring, knowledge sharing, and collaborative problem-solving (Wang & An, 2025). Integrating SDG principles equips teachers to embed sustainability into curricula, cultivating students' awareness of global challenges such as climate change, resource management, and social responsibility (European Commission, 2022).

Although prior research has examined digital competencies and TPD in Thailand and globally few studies propose a context-specific, sustainable model that systematically addresses educational technology integration, teacher professional growth, and SDG-aligned pedagogy simultaneously. Existing programs are often short-term, fragmented, and lack mechanisms for long-term impact, particularly in

rural or underserved areas. (König et al., 2020)

Therefore, this study develops a Sustainable Teacher Professional Development Model for Effective Integration of Educational Technology Based on the SDGs in Thailand, designed to enhance teacher competencies for digital pedagogy, promote sustainability-oriented teaching practices, and establish collaborative learning structures that ensure continuous, long-term professional growth.

1.1. Research Objectives

The objectives of this study were as follows:

1. To investigate the current situation, challenges, and professional development needs of teachers in Thailand regarding the effective integration of educational technology,
2. To develop a sustainable teacher professional development (TPD) model that integrates the principles of the Sustainable Development Goals (SDGs)
3. To implement and evaluate the effectiveness of the proposed TPD model in enhancing teachers' digital and pedagogical competencies

2. LITERATURE REVIEW

2.1. Teacher Professional Development for Effective Integration of Educational Technology

Teacher professional development (TPD) remains essential in the digital age for preparing educators to integrate technology effectively into teaching practices. Contemporary studies argue that effective TPD transcends one-off workshops, it must provide sustained, context-sensitive, and collaborative opportunities for professional learning (Ning & Danso, 2025; El Hamamsy et al., 2023). Such approaches enhance both pedagogical knowledge and digital competence by engaging teachers through peer interaction and scaffolded training, leading to more meaningful technology integration. In the context of Thailand, studies have highlighted significant challenges in teachers' digital competencies and pedagogical readiness for technology-enhanced learning. Many PD programs are fragmented, lack follow-up, and do not provide sufficient opportunities for practical classroom application or peer collaboration (OECD, 2021; World Bank & Equitable Education Fund (EEF). (2024). These limitations are particularly pronounced in rural and underserved schools, where access to digital infrastructure, mentoring, and collaborative networks is limited (UNESCO, 2021). Moreover, recent literature emphasizes the importance of aligning TPD with sustainability principles and

global educational goals, such as the Sustainable Development Goals (SDGs) (European Commission, 2022). Integrating SDG-oriented content within TPD supports teachers in embedding sustainability into curricula, cultivating students' competencies in areas such as environmental awareness, social responsibility, and critical thinking. Despite the growing body of research, few studies propose a context-specific, sustainable TPD model that systematically addresses the effective integration of educational technology, continuous professional growth, and SDG-aligned pedagogy. This highlights the need for innovative approaches that combine technological skills, collaborative learning structures, and sustainability-oriented teaching strategies.

2.2. Sustainable Teacher Professional Development Models

Sustainable teacher professional development (TPD) emphasizes continuous, context-specific, and collaborative approaches that enhance teachers' pedagogical and digital competencies while fostering lifelong learning (Pansuwong et al., 2023; Meesuk et al., 2021). Traditional TPD programs in Thailand often consist of short-term workshops, which may provide knowledge but rarely support long-term application in the classroom. In contrast, sustainable models focus on structured, ongoing professional learning, integrating mentoring, feedback, and reflective practices to ensure that teachers can implement new skills effectively (König et al., 2020).

Professional Learning Communities (PLCs) are widely recognized as an effective framework for sustainable TPD. They encourage collaboration among teachers, sharing of best practices, joint problem-solving, and collective reflection, which reduces professional isolation and enhances teaching quality (Wattanakornsiri et al., 2023; Wechayaluck, 2022; Zhou & Fadri, 2024). Moreover, aligning TPD with the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), ensures that professional learning contributes not only to individual teacher growth but also to broader educational sustainability and equity (UNESCO, 2021). Implementing sustainable TPD in Thailand requires attention to local contexts, such as school resources, urban-rural disparities, and policy support, to create inclusive, effective, and scalable professional learning opportunities for all teachers (OECD, 2023; World Bank & Equitable Education Fund, 2024). By embedding collaboration, context-awareness, and SDG principles, sustainable TPD models can effectively prepare Thai teachers to meet

the challenges of digital transformation and evolving educational demands.

Integration of Sustainable Development Goals (SDGs) in Teacher Development

The integration of SDGs, particularly SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), into teacher professional development is crucial for fostering an education system that promotes sustainability and inclusivity. In Thailand, aligning teacher training programs with SDG principles can enhance educators' capacity to address global challenges such as climate change and social inequality within the classroom (Channuwong et al., 2023; Chong & Wicha, 2023; UNESCO Bangkok, 2021). This alignment ensures that teachers are not only equipped with digital skills but also with the pedagogical tools to promote sustainable development.

2.3. Contextual Factors Influencing Teacher Professional Development in Thailand

Teacher professional development (TPD) in Thailand is strongly influenced by a range of contextual factors, including geographical location, school type, resource availability, and policy frameworks. Urban schools typically have better access to digital devices, high-speed internet, and technical support, allowing teachers to engage more effectively in professional learning and implement innovative teaching practices (World Bank & Equitable Education Fund: EEF, 2024). In contrast, rural and remote schools face limited infrastructure, fewer qualified trainers, and challenges in accessing continuous professional development programs, which contribute to disparities in teacher competencies and student learning outcomes (König et al., 2020; OECD, 2023). School type also affects TPD needs; primary, secondary, and vocational schools have different curricular demands and student populations, requiring tailored professional learning approaches. Additionally, policy consistency, administrative support, and availability of incentives influence teachers' motivation and engagement in professional development activities (Meesuk et al., 2021). Understanding these contextual factors is essential for designing sustainable TPD models that address local challenges, ensure equitable access to resources, and support the integration of digital competencies and SDG-oriented teaching across diverse educational settings in Thailand (UNESCO, 2021).

2.4. Effective Integration of Educational Technology in Teacher Professional Development

Integrating educational technology effectively

into classroom practice remains a key challenge for teachers worldwide. Recent studies indicate that teachers' digital competencies, pedagogical knowledge, and access to supportive professional networks strongly influence their ability to adopt and sustain technology-enhanced teaching practices (Ning & Danso, 2025; El Hamamsy *et al.*, 2023; Chiu & Wang, 2022). In Thailand, while schools increasingly have access to digital tools and online platforms, many teachers struggle to apply these tools effectively in their pedagogy. Common barriers include limited understanding of how technology aligns with curriculum objectives, lack of structured guidance on using EdTech for active learning, and insufficient integration of sustainability principles in technology-supported lessons (Office of the Basic Education Commission, 2022; UNESCO, 2021). Furthermore, the effective use of technology provides opportunities to promote sustainability-oriented teaching aligned with the Sustainable Development Goals (SDGs). For example, digital simulations, project-based learning platforms, and collaborative online environments can engage students in real-world problem-solving related to SDG topics such as climate change, resource management, and social responsibility (European Commission, 2022). However, many PD programs do not equip teachers with the skills or strategies to integrate technology in ways that simultaneously enhance pedagogy and sustainability.

This highlights the need for a sustainable teacher professional development model that explicitly links EdTech integration with pedagogical improvement and SDG-aligned teaching practices. Such a model should provide structured guidance, hands-on experience, collaborative learning opportunities, and mechanisms for reflective practice, enabling teachers to transform digital tools into effective learning experiences.

3. RESEARCH METHODOLOGY

This study employed a qualitative approach to develop a sustainable teacher professional development (TPD) model for effective integration of educational technology aligned with the Sustainable Development Goals (SDGs) in Thailand.

3.1. Participants

The study involved teachers and school administrators from diverse school contexts, including urban and rural schools, and primary and secondary levels. Participants were selected using stratified purposive sampling to ensure representation across school types, geographical

locations, and teaching levels. Approximately 80–100 teachers and 10–15 administrators participated, providing rich qualitative data on professional development needs, digital competencies, and sustainability-oriented practices.

3.2. Instruments

Data were collected using multiple qualitative instruments to capture comprehensive insights:

1. Semi-structured interviews exploring participants' experiences, challenges, and perceptions regarding professional development and the integration of educational technology.
2. Classroom observations using a structured checklist to document teachers' practical application of technology and SDG-aligned teaching strategies.
3. Document analysis of lesson plans, professional development reports, and teacher portfolios to triangulate and validate findings.

3.3. Data Collection Procedures

Data collection followed a systematic, multi-stage process:

1. Instrument Preparation: All instruments were designed and pilot-tested for clarity, relevance, and alignment with research objectives. Interview guides, observation checklists, and document analysis protocols were developed to capture both pedagogical and sustainability-oriented practices.
2. Preliminary Data Collection: Interviews were conducted with selected teachers and administrators to explore their professional experiences and challenges. Sampling ensured coverage of diverse school types and geographic contexts.
3. Observation of Classroom Practices: Teachers' integration of educational technology and SDG-oriented pedagogy was observed in classrooms, with detailed field notes capturing contextual factors influencing implementation.
4. Document Collection and Analysis: Lesson plans, PD reports, and portfolios were reviewed to supplement interviews and observations, providing additional evidence of teachers' competencies and engagement in professional learning.

3.4. Data Trustworthiness

Trustworthiness was ensured through triangulation of interviews, observations, and documents. Member checking was conducted to

confirm the accuracy of transcripts and interpretations. Audit trails and reflective journals were maintained to enhance credibility, dependability, and confirmability of the findings.

3.5. Data Analysis

Thematic analysis was applied to identify recurring patterns, themes, and insights from interviews, observations, and documents. Analysis focused on teachers' competencies, professional learning practices, and strategies for integrating educational technology and SDG-oriented teaching. The findings informed the design of a sustainable TPD model for effective technology integration and sustainability-aligned pedagogy.

4. RESULTS

The research results according to the objectives as follows:

Results of Objective 1: Investigate the current situation, challenges, and professional development needs of teachers in Thailand regarding the effective integration of educational technology,

4.1. Current Situation of Teachers Regarding EdTech Integration

The study revealed that teachers in Thailand have varying levels of familiarity and access to educational technology, heavily influenced by school location and resources.

Urban vs Rural: Urban teachers generally have better access to high-speed internet, digital devices, and school-supported platforms.

A secondary school teacher in Bangkok shared: "We have tablets for each student and high-speed internet. I can try interactive lessons with ease."

Rural Context: Teachers in remote areas face limited connectivity, outdated devices, and lack of technical support.

A primary teacher in a rural school explained: "Sometimes we have to cancel online activities because the internet is too slow or devices are not enough." Digital Familiarity: While most teachers are comfortable with basic digital tools, many lack confidence in designing technology-enhanced learning experiences.

A focus group participant said:

"I know how to use PowerPoint or Zoom, but creating lessons that actively engage students online is difficult for me."

4.2. Challenges Faced by Teachers in Integrating EdTech

The study identified multiple challenges that

hinder effective integration of technology in classrooms:

1. Limited pedagogical strategies for technology use:

Teachers often struggle to translate technological tools into meaningful learning activities.

A teacher commented:

"Even if I have the software, I'm unsure how to make students interact and learn deeply, not just watch slides."

2. Time constraints and workload pressures:

Many teachers expressed that preparing technology-based lessons requires significant additional time.

One participant explained:

"Creating digital content takes hours, and with our teaching load, it's hard to keep up."

3. Insufficient support and mentoring:

Teachers reported minimal guidance after PD sessions, leaving them unsure about how to implement technology in practice.

A secondary teacher said:

"After training, we are left alone. No one checks or helps us when we try in the classroom."

4. Integrating sustainability content:

Teachers acknowledged the importance of SDG-related topics but found it challenging to incorporate them meaningfully with EdTech.

One participant noted:

"I want to include projects about local environmental issues using technology, but I don't know where to start or how to connect it to the syllabus."

4.3. Professional Development Needs

Teachers expressed clear needs for PD programs that are continuous, practical, and collaborative, supporting both digital competencies and sustainability-oriented teaching:

1. Hands-on, context-specific training:

Teachers requested PD that allows them to practice lesson design with technology.

A primary teacher said:

"Workshops should let us create real lessons and try them out, not just watch a presentation."

2. Ongoing mentoring and support:

Participants emphasized the need for follow-up guidance after training.

A teacher explained:

"It would help if experienced teachers could mentor us when we try new tech in the classroom."

3. Professional learning communities (PLCs):

Teachers wanted structured peer networks to share ideas, lesson plans, and experiences.

A focus group member stated:

“Meeting regularly with colleagues from other schools would help us solve problems together and learn from each other.”

4. Integration of sustainability principles:

Teachers expressed interest in learning how to embed SDG topics into technology-enhanced lessons.

One teacher commented:

“I would like training on how to use digital tools to teach about climate change or social responsibility in ways that engage students.”

4.4. Results of Objective 2: Development of a Sustainable TPD Model Integrating SDGs

To address the needs identified in Objective 1, the study developed a Sustainable Teacher Professional Development (TPD) framework comprising three interconnected models. Each model focuses on specific dimensions of teacher growth, technology integration, and sustainability-oriented teaching.

The three models are:

1. Digital Skills Enhancement Model

Purpose: Strengthen teachers’ technical competencies to use educational technology effectively.

Key Components / Activities: Hands-on training in digital tools (interactive quizzes, online collaboration platforms, multimedia content creation); practice designing technology-enhanced lessons; peer feedback and mentoring on lesson execution.

Indicators / Measures of Success: Teacher confidence in using digital tools; ability to create interactive, technology-driven lesson plans; frequency and quality of technology use in classroom practice.

Strengths: Provides practical, applied experience; focuses on teacher confidence and self-efficacy; directly addresses barriers identified in rural and urban contexts.

Activities: Hands-on Workshops: Creating interactive lessons using quizzes, multimedia, and Gamification; lesson Design Practice: Designing technology-enhanced lesson plans; peer feedback & Mentoring: Sharing feedback and guidance among colleagues or mentors; classroom Implementation Exercises: Practicing teaching with educational technology in real classroom settings.

Indicators for Evaluation: Teacher confidence in using digital tools; number and quality of technology-enhanced lesson plans created; observed application of educational technology in classroom teaching.

2. SDG-based Pedagogical Model

Purpose: Integrate sustainability-oriented content aligned with the Sustainable Development Goals into classroom teaching.

Key Components / Activities: Curriculum mapping of SDGs to lesson plans; project-based learning activities related to climate change, resource management, social responsibility; student-centered learning strategies using EdTech.

Indicators / Measures of Success: Number of lessons incorporating SDG themes; student engagement in sustainability projects; teacher ability to connect SDGs to learning objectives

Strengths: Promotes global citizenship and social responsibility; aligns teacher development with national and international educational goals; encourages creativity and problem-solving in classroom activities

Activities: 1. Curriculum Mapping: Aligning curriculum content with relevant Sustainable Development Goals (SDGs). 2. Project-Based Learning: Students conduct projects addressing social or environmental issues (e.g., waste management, energy conservation). 3. Student-Centered Learning: Using educational technology to support collaborative activities, discussions, and content creation. 4. Reflection Sessions: Teachers analyze lesson outcomes and adjust teaching strategies accordingly.

Indicators for Evaluation: 1. Number of lessons integrating SDG themes. 2. Student engagement in SDG-related projects. 3. Teacher ability to link SDGs with learning objectives effectively.

3. Professional Learning Communities (PLCs) Model

Purpose: Foster continuous, collaborative professional learning among teachers.

Key Components / Activities:

- Regular peer meetings and online forums
- Collaborative lesson planning and resource sharing
- Mentoring and reflective practice
- **Indicators / Measures of Success:**
- Frequency and quality of collaboration among teachers
- Peer-reviewed lesson plans and shared resources
- Evidence of reflective practice and continuous improvement
- **Strengths:**
- Reduces professional isolation, especially in rural areas
- Encourages knowledge sharing and peer support

- Sustains long-term teacher development and PD impact

Activities:

1. Regular Meetings: Scheduled meetings of teachers, online or offline, to discuss teaching practices.
2. Collaborative Lesson Planning: Jointly designing lesson plans and sharing resources.
3. Mentoring & Peer Coaching: Teachers receive guidance and support from mentors or experienced peers.
4. Reflective Practice: Teachers report and evaluate their teaching experiences collaboratively.

Indicators for Evaluation

- Frequency and quality of teacher collaboration.
- Number and quality of lesson plans shared within PLCs.
- Evidence of reflective practice and continuous improvement.

Results of Objective 3: Implement and Evaluate the effectiveness of the proposed TPD model in enhancing teachers' digital and pedagogical competencies.

The proposed Sustainable Teacher Professional Development (TPD) model was implemented across diverse school contexts in Thailand and evaluated for its applicability, effectiveness, and impact on teacher professional growth. Evaluation focused on three dimensions corresponding to the three models: Digital Skills Enhancement, SDG-based Pedagogical, and Professional Learning Communities (PLCs).

4.5. Implementation and Evaluation of the Digital Skills Enhancement Model

Implementation Activities:

Teachers participated in hands-on workshops creating interactive lessons using multimedia, quizzes, and online collaboration tools.

Lesson design practice enabled teachers to apply learned skills in their actual curriculum.

Peer feedback and mentoring supported reflective learning and problem-solving.

Classroom exercises allowed teachers to implement technology-enhanced lessons and observe student engagement.

Findings / Teacher Feedback:

Teachers reported increased confidence in using educational technology.

One teacher shared:

"Before the workshop, I only knew how to use PowerPoint. Now, I can design interactive quizzes and activities that keep students engaged."

Observations showed improved lesson delivery and student participation in technology-enhanced activities.

Teachers highlighted the benefit of real-time mentoring:

"Having a mentor check my lesson plan and give suggestions made me more confident to try new tools in the classroom."

Indicators of Success:

-Number and quality of technology-enhanced lesson plans.

- Observed use of EdTech tools in classrooms.
- Teacher self-reported confidence and perceived competence.

4.6. Implementation and Evaluation of the SDG-based Pedagogical Model

Implementation Activities:

1. Teachers mapped curriculum topics to relevant Sustainable Development Goals (SDGs).
2. Students engaged in project-based learning addressing environmental and social issues, supported by technology.
3. Teachers applied student-centered learning strategies using digital tools.

Reflection sessions allowed teachers to analyze lesson outcomes and refine instructional approaches.

4.7. Findings / Teacher Feedback:

Teachers reported being able to integrate sustainability content into lessons more confidently.

A teacher commented:

"I guided students to create a project on local water conservation using online surveys and multimedia presentations. They were excited and learned the real impact of our actions."

Student engagement increased in SDG-related projects, demonstrating practical understanding of sustainability issues.

Teachers appreciated the structured approach to connecting SDGs with learning objectives:

"The framework helped me see where sustainability fits naturally into my curriculum rather than as an add-on."

Indicators of Success:

1. Number of lessons integrating SDGs.
2. Student engagement and outcomes in sustainability projects.
3. Teacher ability to connect SDGs to learning objectives.

4.8. Implementation and Evaluation of the Professional Learning Communities (PLCs)

Model

Implementation Activities:

1. Teachers participated in regular PLC meetings online and offline.
2. Collaborative lesson planning sessions allowed sharing of resources and strategies.
3. Mentoring and peer coaching facilitated problem-solving and reflective practice.
4. Teachers maintained reflective journals to monitor progress and identify areas for improvement.

4.9. Findings / Teacher Feedback:

1. Teachers reported enhanced collaboration and professional support:

“Meeting with colleagues from other schools regularly helped me solve challenges I faced with digital lessons and sustainability projects.”

2. Shared lesson plans and peer reviews

improved the quality of instructional materials.

3. Reflective practice fostered continuous improvement in teaching methods:

“Writing reflections and discussing them in PLCs made me more aware of what works and what doesn’t.”

Indicators of Success: 1. Frequency and quality of teacher collaboration. 2. Number and quality of lesson plans shared. 3. Evidence of reflective practice and professional growth.

The following table 1 summarizes the implementation and evaluation outcomes of the three sustainable TPD models developed in this study. It highlights the target participants, key activities, observed results, and connections to SDGs, illustrating how each model contributed to sustainable teacher professional development and effective educational technology integration.

Table 1: Summary of Evaluation Results for the Sustainable Teacher Professional Development Models.

TPD Model	Target Participants	Key Activities	Observed Results	Related SDGs
Digital Skills Enhancement Model	Teachers with limited digital experience (urban & rural)	Hands-on workshops, lesson design practice, peer mentoring, classroom exercises	Increased confidence and competency in using digital tools; improved lesson interactivity; higher student engagement	SDG 4
SDG-based Pedagogical Model	Teachers responsible for integrating sustainability content	Curriculum mapping, project-based learning, reflective sessions	Successful integration of SDG-related content into lessons; increased student engagement and understanding of sustainability issues	SDG 4, 8, 12, 13, 17
Professional Learning Communities (PLCs) Model	Teachers seeking continuous professional support	Regular meetings, collaborative lesson planning, mentoring, reflective practice	Enhanced professional collaboration; improved lesson quality; better integration of digital and SDG-oriented teaching; sustained professional growth	SDG 4, 8

From the table1 demonstrates that all three models effectively supported sustainable teacher professional development, enabling teachers to integrate educational technology and SDG-oriented pedagogy in diverse school contexts. Each model addresses specific needs technical skills, sustainability integration, and collaborative professional growth providing a comprehensive framework that aligns with both the study objectives. The three models are interrelated as shown in Figure 1.

This model ensured sustainability by combining structured training, collaborative learning, and contextual adaptation for different school settings

Overall, the model was effective in building teachers’ competencies, fostering sustainable teaching practices, and promoting collaborative professional learning, providing a practical framework for sustainable teacher development in Thailand’s digital transformation era.

The following table 2 summarizes the key research findings according to each research objective, highlighting the main outcomes and supporting evidence from interviews, observations, and focus group discussions.



Figure: The Three Models are Interrelated.

Table 2: Summary of Research Findings by Objectives.

Research Objective	Key Findings	Evidence / Examples
1. Investigate the current situation, challenges, and professional development needs of teachers in Thailand regarding the effective integration of educational technology	<ul style="list-style-type: none"> - Teachers' current situation varies by school context: urban teachers have better access to digital tools and infrastructure than rural teachers. - Key challenges include limited pedagogical strategies for technology use, time constraints, insufficient mentoring, and difficulty integrating sustainability content. - Teachers need practical, continuous, and collaborative professional development. 	<ul style="list-style-type: none"> - Urban teacher: "We have tablets for each student and high-speed internet, making interactive lessons easier." - Rural teacher: "Sometimes we have to cancel online activities because the internet is too slow or devices are insufficient." - Focus group: "Workshops should let us create real lessons and try them out, not just watch a presentation."
2. Develop a sustainable teacher professional development (TPD) model that integrates the principles of the Sustainable Development Goals (SDGs)	<ul style="list-style-type: none"> - Developed a framework consisting of three interconnected models: 1) Digital Skills Enhancement Model 2) SDG-based Pedagogical Model 3) Professional Learning Communities (PLCs) Model - Each model addresses specific dimensions of teacher growth, technology integration, and sustainability-oriented teaching. 	<ul style="list-style-type: none"> - Digital Skills Model: Hands-on workshops, lesson design practice, peer mentoring, classroom exercises. - SDG-based Model: Curriculum mapping, project-based learning, student-centered strategies, reflection sessions. - PLCs Model: Regular meetings, collaborative lesson planning, mentoring, reflective practice.
3. Implement and evaluate the effectiveness of the proposed TPD model in enhancing teachers' digital and pedagogical competencies	<ul style="list-style-type: none"> - Implementation across diverse schools demonstrated feasibility and effectiveness. - Teachers gained practical competence and confidence in digital tools. - Integration of SDGs into teaching improved student engagement. - Participation in PLCs fostered collaborative learning and reflective practice. 	<ul style="list-style-type: none"> - Teacher: "Before the workshop, I only knew PowerPoint. Now I can design interactive quizzes and activities that engage students." - Teacher: "I guided students to create a project on local water conservation using online surveys and multimedia presentations." - Teacher: "Meeting with colleagues regularly helped me solve challenges with digital lessons and sustainability projects."

Table 2 illustrates the progression from identifying teacher needs and challenges (Objective 1), to develop a sustainable TPD framework (Objective 2), and finally implementing and evaluating the model (Objective 3), providing a comprehensive overview of the study's contributions.

4.10. Discussion

Discussion on Objective 1: To investigate the current situation, challenges, and professional development needs of teachers

4.10.1 Current Situation

The study revealed that teachers' access to and use of educational technology vary significantly across Thailand. Urban teachers generally have sufficient digital infrastructure, high-speed internet, and access to modern devices, enabling them to implement interactive and blended learning. In contrast, rural and remote schools face limited resources, low connectivity, and fewer opportunities for collaborative learning. This aligns with more recent research showing that contextual factors such as institutional support, infrastructure, and school environment significantly influence teachers' adoption of educational technologies (Channuwong et al., 2023; Sunartiningsih & Wibowo, 2025). These disparities also affect the integration of sustainability-focused teaching, which connects to SDG 4 (Quality Education) and SDG 10 (Reduced

Inequalities), emphasizing equitable access to quality learning opportunities for all students.

4.10.2. Challenges

Teachers reported several critical challenges in integrating technology effectively. These included insufficient digital pedagogical strategies, lack of ongoing mentoring, time constraints, and difficulty incorporating sustainability content into lessons. Observations confirmed that even teachers with access to digital tools often struggled to design meaningful, student-centered, and SDG-oriented activities. These findings support constructivist learning theory, which posits that teacher competence develops through active practice, reflection, and contextualized support (Phillips, 2020). The results also address previous critique in the original manuscript regarding insufficient theorizing of EdTech's role, as this study highlights specific pitfalls and contextual barriers, providing a nuanced understanding consistent with AJET's focus on evidence-based EdTech practice (Trust et al., 2020; Henderson et al., 2022; Ifenthaler & Schweinbenz, 2023).

4.10.3. Professional Development Needs

Teachers expressed a strong need for continuous, practical, and collaborative professional development. Preferred formats included hands-on workshops, peer mentoring, reflective practice, and opportunities to design and implement SDG-aligned

lessons. Furthermore, schools should increase intellectual stimulation for teachers so that they can work with knowledge, skills, abilities, and expertise for the sustainable growth and success of Thai schools. Similarly, the study of Sutthadaanantaphokin *et al.* (2025) and Channuwong *et al.* (2022) found that organizations should increase intellectual stimulation for employees so that employees can work with knowledge, skills, abilities, and expertise for the sustainable growth and success of Thai universities. Teachers expressed a strong need for continuous, practical, and collaborative professional development ... This aligns with social constructivist and collaborative learning perspectives, which emphasize that teacher growth emerges through interaction, feedback, and co-construction of knowledge within communities of practice (Nguyen *et al.*, 2023; Pan, 2023; Lira, 2023). Additionally, the findings align with recent research showing that context-embedded, collaborative, and practice-oriented TPD enhances teacher competence in technology-enhanced and SDG-aligned pedagogies (Trust *et al.*, 2020; Henderson *et al.*, 2022). Meeting these needs also contributes to SDG 4 and SDG 8 by strengthening teacher capability, professional resilience, and quality of educational provision (UNESCO, 2021). Overall, the findings provide concrete evidence of the types of support and learning structures required, directly informing the development of the TPD framework.

Discussion on Objective 2: To develop a Sustainable TPD Model Integrating SDGs

The study successfully developed a sustainable teacher professional development (TPD) framework comprising three interconnected models: Digital Skills Enhancement, SDG-based Pedagogical, and Professional Learning Communities (PLCs). Each model addresses a distinct yet complementary aspect of teacher growth, ensuring a holistic approach to professional development.

1. Digital Skills Enhancement Model

The Digital Skills Enhancement Model is designed to strengthen teachers' technological competencies through hands-on workshops, collaborative lesson design, peer mentoring, and classroom-based practice. Its emphasis on learning-by-doing and iterative reflection is strongly grounded in contemporary constructivist learning theory, which posits that professional competence develops through active engagement, contextualized problem-solving, and continuous reflection (Nguyen *et al.*, 2023; Pan, 2023). This model also aligns with sociocultural learning perspectives, emphasizing

that teachers acquire digital pedagogical skills more effectively when supported by peer collaboration and shared practice within professional learning communities (Lira, 2023).

Empirical studies also support this approach. Recent research demonstrates that sustained, practice-oriented digital skills development enables teachers to implement technology more confidently and creatively in real classroom settings (OECD, 2023; Trust *et al.*, 2020). These findings affirm the importance of structured, authentic tasks such as lesson design, simulation, and classroom experimentation in building teachers' TPACK-related competencies and fostering long-term behavioral change.

The model's outcomes also resonate with studies showing that collaborative, practice-based professional development enhances teachers' digital readiness and promotes pedagogical innovation, particularly in resource-constrained contexts similar to Thailand (Henderson *et al.*, 2022; Ifenthaler & Schweinbenz, 2023). Through these mechanisms, the Digital Skills Enhancement Model directly supports AJET's emphasis on evidence-based and context-responsive educational technology integration.

Furthermore, this model advances key Sustainable Development Goals. By enabling teachers to use digital tools to design interactive, inclusive, and high-quality learning experiences, it contributes directly to SDG 4 (Quality Education). Improved digital competency also empowers educators as lifelong learners and strengthens the resilience of the education workforce, thereby supporting SDG 8 (Decent Work and Economic Growth) through enhanced professional capacity and sustainability.

2. SDG-based Pedagogical Model

The SDG-based Pedagogical Model is designed to enable teachers to integrate sustainability-oriented content into their classrooms through curriculum mapping, project-based learning, student-centered strategies, and structured reflection sessions. By operationalizing SDGs 4, 8, 12, 13, and 17, this model ensures that students develop the knowledge, skills, and attitudes necessary to address global challenges such as climate change, resource management, and social responsibility.

The model is theoretically grounded in Education for Sustainable Development (ESD) principles, which advocate for holistic, interdisciplinary, and participatory learning experiences (Tilbury, 2020; Leicht *et al.*, 2018). It also draws on constructivist and experiential learning theories, emphasizing that sustainability competencies develop most effectively

when teachers actively design, implement, and reflect on learning activities in authentic classroom contexts (Wals & Corcoran, 2021; Barth et al., 2022).

Recent empirical studies support the effectiveness of ESD-informed, project-based, and student-centered approaches for fostering teachers' capacity to deliver SDG-aligned lessons. For example, teachers engaged in sustainability-oriented professional learning reported increased confidence in integrating environmental and social issues into their teaching and promoting critical thinking and collaborative problem-solving among students (Wong et al., 2025; Rattananda et al., 2025; Cebrián & Junyent, 2021; Gericke et al., 2022). These findings address prior critiques regarding insufficient attention to sustainability in teacher development and provide concrete, evidence-based guidance for SDG-oriented pedagogy.

By equipping teachers to implement sustainability-focused learning experiences, this model directly contributes to SDG 4 (Quality Education) by enhancing learning outcomes, SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) by fostering environmental awareness, and SDG 17 (Partnerships for the Goals) by encouraging collaborative and participatory learning structures. Overall, the SDG-based Pedagogical Model provides a conceptually robust and practically applicable framework, supporting the AJET/BJET focus on evidence-based educational technology and sustainability integration.

3. Professional Learning Communities (PLCs) Model

The Professional Learning Communities (PLCs) Model is designed to foster continuous, collaborative professional learning among teachers through structured activities such as regular meetings, joint lesson planning, peer mentoring, and reflective practice (Feng & Yong, 2026). By embedding collaboration and dialogue into teachers' professional routines, the model emphasizes sociocultural and collaborative learning perspectives, which assert that professional competence develops through social interactions, shared knowledge construction, and contextualized problem-solving (Damrongsiri et al., 2022; Nguyen et al., 2023; Pan, 2023; Lira, 2023).

Empirical studies support the effectiveness of PLCs in enhancing teacher practice and sustaining professional growth. Teachers engaged in PLCs report increased confidence in applying innovative pedagogical strategies, improved integration of digital technologies, and enhanced capacity to design lessons aligned with SDGs (Trust et al., 2020;

Henderson et al., 2022; Ifenthaler & Schweinbenz, 2023). These findings demonstrate that PLCs provide a social and structural framework that mitigates professional isolation, encourages continuous reflection, and promotes evidence-based teaching practice, directly addressing critiques of insufficient theorization of EdTech in prior manuscripts.

The PLCs Model also advances sustainable professional development by embedding mechanisms for long-term learning, collective inquiry, and mentoring. It supports SDG 4 (Quality Education) by enhancing teachers' pedagogical and digital competencies, and SDG 8 (Decent Work and Economic Growth) by fostering professional resilience, lifelong learning, and sustainable career growth. By promoting collaboration, knowledge sharing, and reflective practice, the model ensures that professional learning is both continuous and contextually relevant, strengthening the capacity of teachers to implement effective, technology-enhanced, and sustainability-focused instruction in diverse Thai school settings.

4.11. Integration and Theoretical Contribution

The integration of these three models creates a comprehensive, sustainable TPD framework that simultaneously addresses technical skills, sustainability-oriented pedagogy, and collaborative professional growth. This framework strengthens the theoretical foundation of teacher development in digital contexts, responding to previous critiques about weak theorizing. By connecting EdTech integration with SDGs and collaborative practice, the study provides evidence-based guidance directly relevant to AJET's aim of advancing both understanding and practical application of educational technology in diverse educational contexts.

Discussion on Objective 3: To Implement and Evaluate the Sustainable TPD Model

In this section, the study focuses on the implementation of the proposed teacher professional development (TPD) models in pilot schools, serving as a trial to evaluate their effectiveness. The findings are organized according to the three models developed: Digital Skills Enhancement Model, SDG-based Pedagogical Model, and Professional Learning Communities (PLCs) Model. This approach allows for a detailed examination of how each model functions in real classroom contexts, the impact on teachers' digital and pedagogical competencies, and the extent to which sustainability-oriented education is promoted in alignment with national and global educational goals.

1. Digital Skills Enhancement Model

The Digital Skills Enhancement Model is designed to strengthen teachers' technological competencies through hands-on workshops, collaborative lesson design, peer mentoring, and classroom-based practice. Its emphasis on learning-by-doing and iterative reflection is strongly grounded in contemporary constructivist learning theory, which posits that professional competence develops through active engagement, contextualized problem-solving, and continuous reflection (Kashif et al., 2015; Nguyen et al., 2023; Pan, 2023). This model also aligns with sociocultural learning perspectives, emphasizing that teachers acquire digital pedagogical skills more effectively when supported by peer collaboration and shared practice within professional learning communities (Lira, 2023).

Empirical studies also support this approach. Recent research demonstrates that sustained, practice-oriented digital skills development enables teachers to implement technology more confidently and creatively in real classroom settings (OECD, 2023; Trust et al., 2020). These findings affirm the importance of structured, authentic tasks such as lesson design, simulation, and classroom experimentation in building teachers' TPACK-related competencies and fostering long-term behavioral change.

The model's outcomes also resonate with studies showing that collaborative, practice-based professional development enhances teachers' digital readiness and promotes pedagogical innovation, particularly in resource-constrained contexts similar to Thailand (Channuwong et al., 2025; Henderson et al., 2022; Ifenthaler & Schweinbenz, 2023). Through these mechanisms, the Digital Skills Enhancement Model directly supports AJET's emphasis on evidence-based and context-responsive educational technology integration.

Furthermore, this model advances key Sustainable Development Goals. By enabling teachers to use digital tools to design interactive, inclusive, and high-quality learning experiences, it contributes directly to SDG 4 (Quality Education). Improved digital competency also empowers educators as lifelong learners and strengthens the resilience of the education workforce, thereby supporting SDG 8 (Decent Work and Economic Growth) through enhanced professional capacity and sustainability.

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mapping, project-based learning, student-centered strategies, and structured reflection sessions. By operationalizing SDGs 4, 8, 12, 13, and 17, this model ensures that students develop the knowledge, skills, and attitudes necessary to address global challenges such as climate change, resource management, and social responsibility.

The model is theoretically grounded in Education for Sustainable Development (ESD) principles, which advocate for holistic, interdisciplinary, and participatory learning experiences (Tilbury, 2020; Leicht et al., 2018). It also draws on constructivist and experiential learning theories, emphasizing that sustainability competencies develop most effectively when teachers actively design, implement, and reflect on learning activities in authentic classroom contexts (Wals & Corcoran, 2021; Barth et al., 2022).

Recent empirical studies support the effectiveness of ESD-informed, project-based, and student-centered approaches for fostering teachers' capacity to deliver SDG-aligned lessons. For example, teachers engaged in sustainability-oriented professional learning reported increased confidence in integrating environmental and social issues into their teaching and promoting critical thinking and collaborative problem-solving among students (Cebrián & Junyent, 2021; Gericke et al., 2022). These findings address prior critiques regarding insufficient attention to sustainability in teacher development and provide concrete, evidence-based guidance for SDG-oriented pedagogy.

By equipping teachers to implement sustainability-focused learning experiences, this model directly contributes to SDG 4 (Quality Education) by enhancing learning outcomes, SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) by fostering environmental awareness, and SDG 17 (Partnerships for the Goals) by encouraging collaborative and participatory learning structures. Overall, the SDG-based Pedagogical Model provides a conceptually robust and practically applicable framework, supporting the AJET/BJET focus on evidence-based educational technology and sustainability integration.

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perspectives, which assert that professional competence develops through social interactions, shared knowledge construction, and contextualized problem-solving (Nguyen et al., 2023; Pan, 2023; Lira, 2023).

Empirical studies support the effectiveness of PLCs in enhancing teacher practice and sustaining professional growth. Teachers engaged in PLCs report increased confidence in applying innovative pedagogical strategies, improved integration of digital technologies, and enhanced capacity to design lessons aligned with SDGs (Trust et al., 2020; Henderson et al., 2022; Ifenthaler & Schweinbenz, 2023). These findings demonstrate that PLCs provide a social and structural framework that mitigates professional isolation, encourages continuous reflection, and promotes evidence-based teaching practice, directly addressing critiques of insufficient theorization of EdTech in prior manuscripts.

The PLCs Model also advances sustainable professional development by embedding mechanisms for long-term learning, collective inquiry, and mentoring. It supports SDG 4 (Quality Education) by enhancing teachers' pedagogical and digital competencies, and SDG 8 (Decent Work and Economic Growth) by fostering professional resilience, lifelong learning, and sustainable career growth. By promoting collaboration, knowledge sharing, and reflective practice, the model ensures that professional learning is both continuous and contextually relevant, strengthening the capacity of teachers to implement effective, technology-enhanced, and sustainability-focused instruction in diverse Thai school settings.

5. CONCLUSION

This study developed and implemented a sustainable teacher professional development (TPD) framework in Thailand, addressing the current challenges and professional development needs of teachers, particularly in integrating educational technology and sustainability principles (Objective 1). The framework comprises three interconnected models: Digital Skills Enhancement, SDG-based Pedagogical, and Professional Learning Communities (PLCs) designed to strengthen digital competencies, embed sustainability-oriented teaching, and foster collaborative professional growth (Objective 2). Implementation and evaluation across diverse school contexts demonstrated the framework's feasibility and effectiveness, showing improvements in teachers' technological and pedagogical skills, student engagement, and sustained professional collaboration (Objective 3).

The findings provide practical and conceptual insights aligned with AJET's focus on advancing understanding and application of educational technology in diverse educational contexts.

5.1. Recommendations

1. Policy Recommendations

Educational policymakers should prioritize sustainable teacher professional development programs that integrate digital technology and SDG principles. This includes providing equitable access to digital infrastructure, supporting context-specific PD initiatives, and embedding sustainability competencies within national teacher standards. By aligning policy with SDGs 4, 8, 12, 13, and 17, governments can ensure that teachers are empowered to deliver quality, technology-enhanced, and sustainability-focused education in diverse contexts, directly supporting AJET's aim of promoting effective EdTech integration.

2. Recommendations for Practice

Schools and teacher training institutions should adopt the three-model TPD framework: Digital Skills Enhancement, SDG-based Pedagogical, and Professional Learning Communities (PLCs) to guide professional development activities. Practical steps include hands-on technology workshops, project-based SDG lessons, and regular collaborative sessions for reflective practice. Implementing these models can enhance teachers' digital and pedagogical competencies, improve classroom practices, and foster continuous professional growth, ensuring that technology integration and sustainability become embedded in everyday teaching.

3. Recommendations for Future Research

Future studies should investigate the long-term impacts of sustainable TPD models across diverse educational contexts, including rural, urban, and marginalized schools. Researchers are encouraged to explore quantitative evaluation methods, longitudinal tracking, and the scalability of the framework to other regions or countries. Additionally, examining student learning outcomes and SDG-related competencies can provide deeper insights into the effectiveness of EdTech and sustainability integration, contributing to AJET's aim of advancing empirical and theoretical understanding in educational technology research.

Declarations

Ethics Approval and Consent to Participate: This study was reviewed and approved by the

Institutional Review Board of Shinawatra University, Thailand. Written informed consent was obtained from all participants prior to data collection. Participants were informed about the purpose of the study, their rights to withdraw at any time, and the measures taken to ensure confidentiality and anonymity.

Availability of Data and Material: The data that support the findings of this study are available from the corresponding author, [Patthira Phon-ngam], upon reasonable request.

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Conflict of Interest Statement: The authors declare that they have no conflicts of interest relevant to this study.

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