

## THE COMPETENCE OF APPLYING INFORMATION AND COMMUNICATION TECHNOLOGY IN DEVELOPING LESSON PLANS OF PHYSICS PRE-SERVICE TEACHERS

Tran Ngoc Chat<sup>1</sup>, Ngo Trong Tue<sup>2,\*</sup> and Tuong Duy Hai<sup>1</sup>

<sup>1</sup>*Faculty of Physics, Hanoi National University of Education, Hanoi, Vietnam*

<sup>2</sup>*Faculty of Physics, Hanoi Pedagogical University 2, Phu Tho, Vietnam*

\*Corresponding Author: Ngo Trong Tue, e-mail: [ngotrongtue@hpu2.edu.vn](mailto:ngotrongtue@hpu2.edu.vn)

Received: January 20, 2026. Revised: March 10, 2026. Accepted: March 30, 2026.

**Abstract.** Developing a lesson plan (LP) is a critical task for pre-service teachers, and the quality of the LP directly impacts instructional effectiveness and helps organize student-centered learning activities. Consequently, lesson planning research has attracted significant attention globally. Current research directions focus on the LP framework, lesson planning competence, Information and Communication Technology (ICT) integration, and factors influencing LP development. Despite its importance, the competence of pre-service physics teachers in applying ICT to lesson planning has received little scholarly investigation. The study aims to propose ICT applications in physics LPs that align with the Technological Pedagogical Content Knowledge (TPACK) model, empowering pre-service teachers to effectively integrate ICT into their design. Furthermore, it proposes a rubric to assess ICT application competence in physics LPs. The research methodology utilized the e-Delphi method to develop the assessment rubric and theoretical analysis to identify behavioral indicators for developing LPs that meet TPACK standards. Additionally, a pedagogical experiment was conducted to validate the alignment between these behavioral indicators and student competencies. The research results have identified a rubric for assessing ICT application indicators and defined specific indicators within the TK, CK, PK, TCK, PCK, TPK, and TPACK components when developing physics LPs. These findings are significant as they provide physics education students with a framework for self-assessment and guidance. Moreover, the results contribute to improving teacher training programs by providing a standardized basis for evaluating lesson planning competencies through specific behavioral indicators described in the TPACK model.

**Keywords:** digital competence, ICT, lesson plan, physics pedagogy, TPACK.

### 1. Introduction

Developing an LP is a regular and important task for pre-service teachers, and the quality of the LP directly affects teaching outcomes. Therefore, research on LP development has been a focus for many domestic and international authors in recent decades. An LP is a document that outlines the main features of the teaching process to help teachers achieve teaching objectives and students achieve learning outcomes based on assessments aligned with those objectives [1]. Developing an LP is of great significance in the teaching process. The LP serves as a teaching script that helps the teacher manage the classroom logically; the LP is created by the teacher

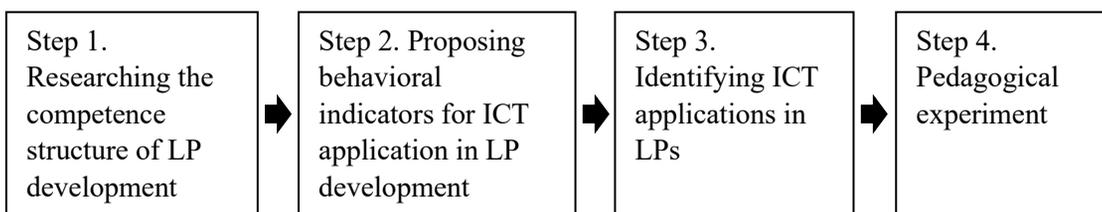
depending on the needs of the class and students [2]. Effective teaching must begin with the successful development of a highly suitable and carefully considered LP. An LP can help teachers understand students' needs to integrate them into the plan, prepare a learning environment for effective teaching, manage lesson activities and time, evaluate the curriculum and the teaching process, bridge the gap between theory and practice, increase teacher confidence, and develop student skills [3]. The importance of the LP is demonstrated through several factors, including: the teacher can approach the lesson content more effectively; the teacher can select appropriate teaching methods for the content and prepare for implementation; preparation of sufficient teaching content; allocation of appropriate time, resources, and facilities; identification of suitable experiential activities for students; and selection of exercises and appropriate assessment methods [4]. The structure of an LP consists of main components such as objectives, teaching equipment, and learning materials (including a description of ICT application), and teaching activities [5]. Some elements that need to be presented in an LP are teaching objectives, subject knowledge, teaching methods, teaching techniques, teaching forms, learning materials, teaching equipment, ICT application, and assessment methods [6]. In an LP for blended learning, it is necessary to describe both digital and printed learning materials as well as the teaching activities that occur in the classroom and online [7], [8]. Thus, the LP needs to describe the ICT applications in teaching physics. For pre-service teachers to develop an LP with ICT applications, they need knowledge of physics content, teaching methods, and the application of ICT in teaching physics that aligns with the TPACK model. Some studies on the integration of ICT in LPs have identified subject-specific behavioral indicators, such as in teaching writing and chemistry, based on the TPACK model [9], [10]. Therefore, it is necessary to investigate the integration of ICT in physics lesson planning grounded in the TPACK model, as well as to develop a rubric for evaluating ICT integration in physics LPs.

This paper proposes indicators for ICT application in the LPs of physics pre-service teachers. The research aims to answer the following questions: (1) What is a suitable rubric for assessing the competence of applying ICT in physics LPs? (2) What indicators describe the application of ICT in physics LPs that meet the TPACK model?

## 2. Content

### 2.1. Methodology

The study was conducted by combining both theoretical and empirical research to assess the ICT application competence of pre-service teachers in developing physics LPs. The research process was carried out as illustrated in Figure 1.



**Figure 1. Research procedure**

*Step 1:* This step aimed to identify the necessary behaviors for developing a physics LP, serving as a basis for proposing behavioral indicators for ICT application within the LP development competence.

*Step 2:* Behavioral indicators for ICT application in LP development competence were identified using the e-Delphi method to seek expert opinions over three rounds. In each round,

experts rated items on a 5-point Likert scale, and each item was accepted if the consensus level was 75% or higher; a third round was not necessary [11], [12]. The evaluation forms were distributed using Google Forms.

*Step 3:* Based on the TPACK model, ICT applications in LPs were identified to determine the suitability of three factors: the application of ICT tools, the physics teaching content, and the teaching methods. Additionally, the ICT application competence in LP development was aligned with the digital competence framework.

*Step 4:* This step aimed to assess the competence level of pre-service teachers in applying ICT in LP development, thereby verifying whether the classification of behavioral indicator levels is appropriate to students' competencies.

## **2.2. Results**

### **2.2.1. The competence structure of LP development**

The research results of Stephan Wernke and Klaus Zierer (2017) propose a competence structure for LP development consisting of: (1) subject-matter competence (understanding and applying the scientific knowledge of the subject); (2) instructional design and organizational competence (the ability to transpose scientific knowledge into teachable knowledge for students, while creating a learning environment that meets students' needs and characteristics); (3) pedagogical competence (the ability to motivate, guide behavior, address emerging problems, and support students' personal development) [13].

Several other studies identify the competence structure for LP development: understanding teaching objectives and environment; analyzing and mastering the curricula and textbooks; selecting learning materials appropriate to students' characteristics; formulating teaching objectives; determining teaching methods, resources, and instructional forms suitable for each topic; designing teaching and learning activities as an integrated process aligned with objectives, content, and methods; gathering reference materials; applying ICT in designing digital design; preparing teaching equipment; and designing and producing simple teaching aids [14], [15].

These studies show that the LP development competence describes key behaviors related to defining instructional objectives, applying subject-matter knowledge, utilizing teaching equipment, and leveraging learning materials (including ICT applications and digital resources). Furthermore, it involves designing instructional activities, aligning lessons with subject themes, planning assessment methods, evaluating, and refining the LP.

### **2.2.2. ICT application competence indicators in LPs**

Within the scope of this paper, the focus is on the indicators of ICT application in the LPs of physics pre-service teachers. To establish expert consensus on the behavioral indicators and their proficiency levels for ICT integration in LPs, opinions were collected from a panel of 16 experts. In each round, experts rated items on a 5-point Likert scale.

*Table 1. Expert characteristics*

<b>Gender</b>		<b>Years of Experience</b>	<b>PhD</b>	<b>Specialization in Theory &amp; Methods of Teaching Physics</b>
<i>Male</i>	<i>Female</i>			
	6	> 10 years	x	X
10		> 10 years	x	X

The selection of experts was based on the following criteria: (1) currently working in professional activities directly related to the education and training of physics students; (2) affiliated with a recognized higher education institution; and (3) holding a doctoral degree

specializing in the Theory and Methodology of Physics Education. The characteristics of the experts are presented in Table 1.

The results of the two e-Delphi rounds are described in the following Table 2.

**Table 2. Results of 2 eDelphi rounds**

Round 1			Round 2		
Mean	SD	% consensus rate	Mean	SD	% consensus rate
<i>Behavioral indicator</i>					
4.4	0.51	100%	4.2	0.40	100%
<i>Level of behavioral indicator</i>					
4.3	0.58	100%	4.1	0.34	100%

After two rounds of e-Delphi, the level of expert consensus on the behavioral indicators for ICT application in LPs reached 100%. Therefore, the third round was not necessary. Based on the results of the two e-Delphi rounds, the ICT application indicators in LPs were identified as presented in Table 3.

**Table 3. ICT Application indicator in LPs**

Indicator	Description
Using ICT applications (online teaching software, assessment support software, subject-specific teaching software, AI tools...)	Utilizing online teaching platforms, supporting online assessment. Employing software to support instructional organization, simulations, video analysis software, and Computer-Based Laboratories (CBL). Integrating AI applications in organizing teaching activities (supporting information retrieval, text summarization, and translation). Applying VR and AR applications to support student learning activities.

The basis for categorizing the proficiency levels of the behavioral competence indicator is the Dreyfus model. [16]. By applying the Dreyfus scale, three proficiency levels are defined in Table 4.

**Table 4. Description of behavioral indicator levels in the competence of developing physics LPs**

Level	Description
Level 1 (Corresponds to Novice)	States or presents the characteristics, role, and structure of the components when developing an LP, but fails to demonstrate the interconnection or alignment with the other instructional elements.
Level 2 (Corresponds to Competent)	States or presents the characteristics, role, and structure of the components when developing an LP while demonstrating the interconnection or alignment with certain other instructional elements.
Level 3 (Corresponds to Proficient)	Analyzes or describes the details in the characteristics, role, and structure of the components when developing an LP while demonstrating a comprehensive interconnection and alignment with all other instructional elements.

This classification was applied to the behavioral indicator for ICT application, followed by two e-Delphi rounds. The results of the expert consultation are presented in Table 2. Based on

expert consensus, the proficiency levels for the behavioral indicator were established as described in Table 5.

**Table 5. Levels of the ICT application behavioral indicator**

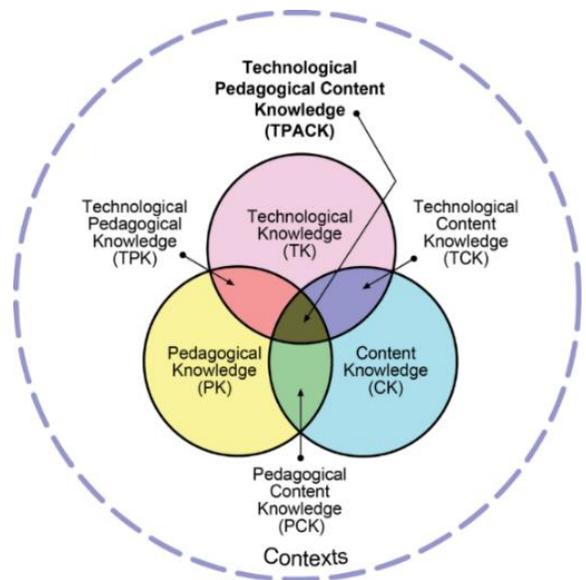
Utilizing ICT applications (online teaching platforms, assessment software, subject-specific tools, and AI-powered applications...)	Level 1 (1 point)	Level 2 (2 points)	Level 3 (3 points)
	State ICT applications while ensuring they meet the technological requirements for instruction.	States ICT applications, ensuring they meet the technological requirements for instruction, and indicates their suitability with specific teaching content.	Describes in detail the ICT applications, ensuring they meet the technological requirements for instruction while demonstrating their alignment with the specific teaching content.

**2.2.3. ICT application in lesson plans meeting the TPACK model and digital competence framework**

**2.2.3.1. The TPACK Model**

In 1986, Shulman defined PCK as the integration of content and pedagogy, highlighting the importance of pedagogical reasoning - how subject matter is transformed into forms that align with students' diverse interests and abilities [17]. Over a five-year longitudinal study, Mishra and Koehler investigated how educators develop effective ways of integrating technology into their teaching practices. This research led to the introduction of the Technological Pedagogical Content Knowledge (TPCK) framework in 2006, (later popularized as TPACK, 2008 [18].

Integrating ICT into teaching gives rise to seven domains of teacher knowledge, as illustrated in Figure 2: Technological Knowledge (TK) regarding digital tools; Content Knowledge (CK) related to the subject matter; Pedagogical Knowledge (PK) involving effective instructional methodologies; Technological Content Knowledge (TCK) focused on using technology to present and transform subject matter; Pedagogical Content Knowledge (PCK) concerning content-specific instruction; Technological Pedagogical Knowledge (TPK) involving the use of technology to support pedagogical strategies; and TPACK, which represents the synergetic knowledge emerging from the dynamic interaction among content, pedagogy, and technology [19].



**Figure 2. Technological pedagogical content knowledge (TPACK) framework**

*(Reproduced by permission of the publisher, © 2012 by tpack.org)*

### 2.2.3.2. Constructing a lesson plan that meets the TPACK model

To design an LP with ICT integration, the TPACK model is employed to align content knowledge, pedagogical strategies, and technological tools. Consequently, it is essential to identify the interplay of CK, PCK, TCK, and TPK throughout the lesson planning process[9]. A profound understanding of TPACK enables educators to effectively integrate ICT into instructional design, which is increasingly recognized as a core component of a teacher's professional competence [20]. To successfully implement the TPACK framework, teachers must have a comprehensive grasp of pedagogical methodologies and their synergy with ICT [21]. Accordingly, pre-service teacher education must focus on training students in diverse ICT applications – such as simulations, virtual laboratories, and digital educational games -to focus their TPACK proficiency and integrative capabilities [22]. With an LP, TPACK is manifested through the strategic use of ICT to present subject matter and facilitate content-specific instruction [10].

The LP must incorporate key factors related to pedagogical methods, instructional techniques, and organizational forms; comprehensive assessment and evaluation plans; and strategic ICT integration [6]. In physics education, ICT applications encompass the use of visual media (images and videos), simulation software, Virtual Reality (VR), and AI-powered tools to facilitate student-centered learning activities [23]-[26]. Specifically, video analysis software is utilized to enhance high school physics instruction [27, 28]. For distance or hybrid learning, platforms such as iSpring, Moodle, and Padlet are employed to manage instructional workflows [29]. In summary, the core applications of ICT in physics teaching include: conducting theoretical lessons and facilitating online collaborative discussions; utilizing multimedia to represent physical concepts; employing simulations (e.g., PhET) to visualize abstract phenomena; integrating video analysis and Computer-Based Laboratories (CBL) for experimental hypothesis testing; leveraging VR technology to immerse students in complex physical systems; and utilizing AI tools for information retrieval, data analysis, and personalized learning pathways.

By analyzing the core characteristics of the TPACK model and ICT integration within physics LPs, the constituent components of TPACK have been identified and categorized, as presented in Table 6.

**Table 6. Description of TPACK components in physics LPs**

<b>TPACK Component</b>	<b>Description</b>
<i>TK</i>	Proficiency in utilizing physics-specific simulation software, video analysis tools, Computer-Based Laboratories (CBL), and online teaching platforms for physics. Knowledge of integrating AI tools to enhance learning. Competence in applying Virtual Reality (VR) and Augmented Reality (AR) to support physics instruction.
<i>CK</i>	Knowledge of the structure and logical sequence of the lesson content. Ability to organize and partition content into coherent lessons.
<i>PK</i>	Knowledge of pedagogical methods, instructional techniques, and organizational forms; competence in designing learning activities and comprehensive assessment plans.
<i>TCK</i>	Knowledge of integrating ICT to present physics concepts.

<i>PCK</i>	Knowledge of implementing pedagogical methods, instructional techniques, and organizational forms to effectively deliver the lesson content. Competence in assessing students throughout the instructional process.
<i>TPK</i>	Knowledge of integrating ICT to facilitate learning activities and assessment strategies.
<i>TPACK</i>	Knowledge of integrating ICT to present subject matter and employing technological tools throughout the instructional process to effectively deliver content and execute assessments.

Based on the analysis of existing literature on LP development and ICT integration, the essential indicators for designing LPs that align with the TPACK framework were identified, with appropriate adjustments and additions. The research findings are presented in Table 7.

**Table 7. Indicators for developing LPs that meet the TPACK model**

<b>TPACK Component</b>	<b>Indicators for developing the LP</b>	<b>References</b>
<i>TK</i>	<ul style="list-style-type: none"> <li>- State the characteristics and pedagogical role of visual media (images and videos) in instruction.</li> <li>- Analyze the features and functionalities of simulation software (e.g., PhET Interactive Simulations, oPhysics), video analysis tools (e.g., Coach, Tracker), and Computer-Based Laboratories (CBL), while demonstrating technical proficiency in their operation.</li> <li>- Examine the characteristics and educational functions of VR, AR technologies, and possess the technical skills to operate VR, AR hardware, and supporting devices.</li> <li>- Outline the role and features of E-learning and B-learning platforms, with proficiency in managing tools such as Google Meet, Zoom, Google Classroom, and Moodle.</li> <li>- Define the strategic role of AI-powered tools in facilitating students' learning.</li> </ul>	[23]-[28], [30]
<i>CK</i>	<ul style="list-style-type: none"> <li>- Analyze the structure and logical sequence of the instructional content sequence and identify the core learning objectives.</li> <li>- Partition the content into coherent lessons.</li> <li>- Determine the required learning outcomes and achievement standards for the topic.</li> </ul>	[6], [14], [15], [31], [32]
<i>PK</i>	<ul style="list-style-type: none"> <li>- Analyze the pedagogical characteristics of instructional methods and active learning techniques in physics teaching.</li> <li>- Examine the features of diverse instructional delivery modes (in-class, online, or blended learning) and select the optimal format.</li> <li>- Demonstrate the technical operation of experimental apparatus and physical models.</li> <li>- Define the pedagogical role and strategic application of physics-problem-solving exercises.</li> </ul>	[6], [14], [15], [31]-[33]

	<ul style="list-style-type: none"> <li>- Formulate measurable instructional objectives and learning outcomes.</li> <li>- Outline diverse assessment strategies and evaluation methods in physics teaching.</li> <li>- Delineate the formal structure of a structural learning activity.</li> </ul>	
<i>TCK</i>	<ul style="list-style-type: none"> <li>- Identify the specific instructional content represented within visual media (images and videos) for a given topic.</li> <li>- Analyze the alignment between the lesson's core content in simulation software, video analysis tools, and Computer-Based Laboratories (CBL).</li> <li>- Determine the specific knowledge content and physical concepts presented through VR and AR technology.</li> <li>- Identify the instructional content embedded within digital documents and E-learning modules.</li> <li>- Critically evaluate the accuracy and pedagogical value of teaching content generated by AI tools.</li> </ul>	[23]-[28], [30]
<i>PCK</i>	<ul style="list-style-type: none"> <li>- Analyze the pedagogical suitability of instructional methods and active learning techniques based on the specific lesson content and student demographics.</li> <li>- Select the optimal instructional delivery mode (in-class, online, or blended learning) for the lesson.</li> <li>- Demonstrate the integration of experimental apparatus and physical models to deliver the lesson's core content.</li> <li>- Select targeted physics exercises and align with the lesson's instructional content.</li> <li>- Propose a comprehensive assessment plan that is congruent with the selected delivery mode.</li> <li>- Design structured learning activities that are aligned with the instructional objectives, subject matter, and teaching format.</li> </ul>	[14], [15], [31], [32], [34]
<i>TPK</i>	<ul style="list-style-type: none"> <li>- Demonstrate the pedagogical application of visual media (images and videos) in physics instruction.</li> <li>- Present the instructional integration of simulation software, video analysis tools, and Computer-Based Laboratories (CBL) to facilitate physics lessons.</li> <li>- Propose strategic frameworks for students to leverage AI-powered tools for information achievement, data analysis, and self-regulated learning.</li> <li>- Differentiate between synchronous (in-class) and asynchronous (online) instructional content within the lesson structure.</li> <li>- Propose integrated in-class and online learning activities.</li> <li>- Utilize ICT applications to facilitate student learning activities and streamline assessment strategies.</li> </ul>	[5], [23], [28]

<i>TPACK</i>	<ul style="list-style-type: none"> <li>- Analyze the strategic integration of visual media (images and videos) to ensure alignment with the instructional methods, techniques, delivery modes, and physics content.</li> <li>- Evaluate the pedagogical application of simulation software, video analysis tools, and Computer-Based Laboratories (CBL) to optimize their congruence with the lesson methodology, format, and subject matter.</li> <li>- Analyze the instructional efficacy of VR and AR technologies, ensuring appropriately mapped to the teaching techniques and physics lesson content.</li> <li>- Propose strategic frameworks for leveraging AI-powered tools to support learning activities appropriately in a way that is consistent with instructional design and lesson objectives.</li> <li>- Differentiate and categorize synchronous (in-class) and asynchronous (online) content to match the selected pedagogical approach and instructional format.</li> <li>- Design integrated learning activities (both in-person and virtual) that are harmonized with the subject matter and active learning methodologies.</li> <li>- Utilize ICT-driven assessment tools that are purposefully aligned with the lesson content and instructional delivery strategy.</li> </ul>	[5], [6], [23]-[28], [30], [33]
--------------	---	---------------------------------

### 2.2.3.3. ICT application competence in lesson plan development in alignment with the digital competence framework

The Digital Competence Framework for learners (issued under Circular No. 02/2025/TT-BGDĐT by the Ministry of Education and Training) specifies the achievement indicators for learners. [35]. For physics pre-service teachers, the competence in integrating ICT into LPs corresponds to several indicators within the framework. These indicators are mapped to the TPACK model and are detailed in Table 8.

**Table 8. Digital competence of physics Pre-service teachers meeting the TPACK model**

<b>Core competences within the Digital Competence Framework for learners</b>	<b>Description of behavioral manifestations for physics pre-service teachers during lesson plan (LP) development</b>	<b>Aligns with which TPACK component</b>
<i>1. Data and information literacy</i>		
1.1. Browsing, searching, and filtering data, information, and digital content	Searching for ICT applications and selecting the optimal tools for physics instruction.	TK
1.2. Evaluating data, information, and digital content	Evaluating the pedagogical suitability of ICT applications in alignment with the lesson content and instructional methodologies for physics education.	TCK, TPK

1.3. Managing data, information, and digital content	Organizing and managing digital assets for physics instruction, including student records and learning artifacts within Learning Management Systems (LMS) (e.g., Google Classroom, Moodle...).	TK
2. Communication and collaboration in a digital environment		<i>Not aligned with the components of TPACK</i>
3. Digital content creation		
3.1. Developing digital content	Utilize specialized software to develop ICT-based instructional resources for physics education (e.g., Crocodile Physics, Coach, Tracker, PhET simulations...), and authoring interactive e-lectures (e.g., using iSpring Suite).	TK
3.2. Integrating and repurposing digital content	Integrating software into Learning Management Systems (LMS) and digital lectures. Customizing and editing digital documents, e-lectures, and simulations to align with the specific physics content.	TK
3.3. Copyright and License Enforcement		<i>Not aligned with the components of TPACK</i>
3.4. Programming		
4. Security		
5. Problem solving		
5.1. Solving technical problems	Demonstrating technical proficiency in software installation, configuring experimental apparatus for computer-based interfaces (CBL), operating VR and AR technologies, and performing basic troubleshooting for software malfunctions.	TK
5.2. Identifying needs and technological solutions	Identifying requirements for software and digital hardware within the LP, and proposing strategic ICT integration solutions for physics instruction.	TCK, TPK
5.3. Using digital technology creatively	Innovatively leveraging ICT applications to facilitate and transform student learning activities within physics education.	TPACK
5.4. Identifying areas for improvement in digital competence	Identifying digital competence gaps and determining the specific instructional content required to enhance ICT integration within physics lesson plans (LPs).	TK

6. Artificial intelligence application		
6.1. Understanding AI (including GenAI)	Analyzing the pedagogical efficacy of AI applications to optimize and personalize student learning experiences within physics education.	TPK
6.2. Using AI ethically and responsibly	Facilitating and guiding students in the ethical and effective use of AI tools to scaffold and enhance their learning process in physics.	TPACK
6.3. Evaluating AI tools	Assessing the pedagogical impact of AI integration on student learning outcomes and engagement within physics education.	TPACK

#### 2.2.4. Experimental Evaluation of ICT Integration Competence in Lesson Planning

To evaluate the proficiency of pre-service teachers in integrating ICT into physics instruction, a pedagogical experiment was conducted. This study assessed student achievement levels based on predefined behavioral indicators.

Subject Profile:

- Sample size: 20 pre-service teachers.
- Academic level: 2nd-year students (4th semester).
- Affiliation: Faculty of Physics, Hanoi Pedagogical University 2.

##### ***Pedagogical experiment process***

To ensure the validity and reliability of the findings, the experiment followed a structured four-step methodology:

*Step 1. Defining LP construction objectives:* The lecturer introduced the specific requirements and learning outcomes for lesson plan (LP) development. Students were tasked with designing LPs for 03 selected lessons from the "Connecting Knowledge with Life" series. A core requirement was the strategic integration of digital media (images, videos, simulations) and AI to facilitate and enhance student learning activities.

*Step 2. Standardizing the physics LP framework:* The lecturer introduced the official lesson plan (LP) framework in accordance with Appendix 4 of Official Dispatch 5512 of the Ministry of Education and Training (MOET) [5]. Students engaged in self-directed research, presenting and analyzing the core components of the LP, to ensure deep understanding. Subsequently, the lecturer and students reached a consensus on the final LP structure. To support the development process, the lecturer provided a Word template, a step-by-step guide for LP construction, and comprehensive descriptions for each component.

*Step 3. Standardizing evaluation criteria for LPs and student competence:* The lecturer introduced the formal evaluation criteria for lesson plans (LPs), clarifying the specific requirements and guiding students to align their decisions with these standards. A primary focus was placed on the ICT integration criterion, ensuring students fully understood how technology should be applied pedagogically. The assessment rubric for student competence was collaboratively reviewed and transparently communicated to ensure all participants understood the performance expectations.

*Step 4. Training on ICT integration in physics education:* The instructional program focused on equipping students with practical skills on ICT-enhanced physics teaching, including the use of experimental videos (e.g., via specialized on YouTube channels): <https://www.youtube.com/playlist?list=PL860B6886A47E5490>, interactive simulations. (e.g,

PhET, OpeClassroom), (e.g., at <https://phet.colorado.edu/vi>, <https://openclassroom.edu.vn>) and AI-driven pedagogy. Students were guided on leveraging AI tools to scaffold learning activities, such as using ChatGPT for information retrieval, data analysis, and the development of problem-solving strategies. Within the scope of this study, the training aimed to align students' LPs with the TPACK framework, specifically measured through three performance indicators: (1) Analyzing the pedagogical alignment of images and videos with the specific instructional methods, techniques, and physics content. (2) Analyzing the integration of simulation software to ensure it complements the delivery format and curriculum requirements. (3) Proposing strategic AI implementation to support learning activities in a way that is technically and pedagogically appropriate for the physics lesson.

*Step 5. Implementation, review, and assessment of LP development:* This stage followed an iterative cycle of construction and evaluation across three distinct physics topics to track the progression of student competence:

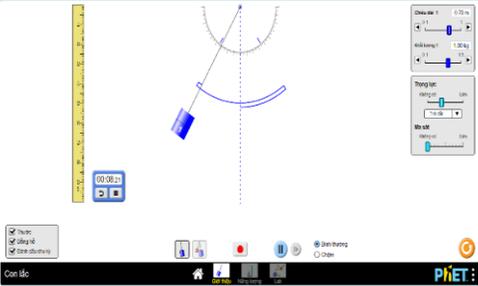
*1st time: Iteration: Projectile motion.* Students developed their initial LPs following the standardized framework. This was followed by a collaborative debriefing where the lecturer and students analyzed the designs. The ICT integration criteria were re-examined to ensure absolute clarity on the expected pedagogical outcomes.

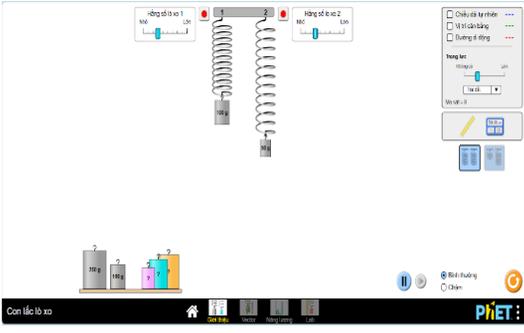
*2nd Iteration: Mechanical energy and the law of conservation of mechanical energy:* Students drafted their second LPs with the lecturer providing targeted feedback, especially on the sophistication and relevance of the ICT applications used to explain energy transformations.

*3rd Iteration: Simple Harmonic Motion.* In the final phase, the lecturer evaluated the LPs and provided strategic guidance on how to scale and adapt these ICT-based instructional products to similar context topics in the physics curriculum.

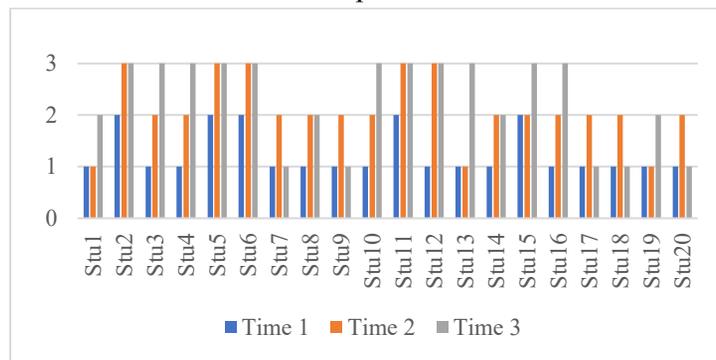
The ICT integration competence was quantitatively and qualitatively measured based on the technical and pedagogical descriptions provided by students within their LPs, as detailed in Table 9.

**Table 9. Analysis of ICT integration in student 14's lesson plan**

No.	Learning Material	Description, function
1	 <p>Video of a guitar string vibration at <a href="https://www.youtube.com/watch?v=xUal2OP8c6w">https://www.youtube.com/watch?v=xUal2OP8c6w</a>.</p>	<p>Video of a guitar string vibration. Utilized as a real-world anchor to demonstrate mechanical oscillation, providing students with visual intuition to scaffold their transition and conceptual connection to the new lesson.</p>
2	 <p>Simple pendulum at <a href="https://phet.colorado.edu">https://phet.colorado.edu</a></p>	<p><i>PhET simulation model of a simple pendulum:</i> A dynamic visualization tool used to model Simple Harmonic Motion (SHM), enabling students to observe and analyze the precise oscillatory behavior of a pendulum in a controlled, virtual laboratory environment.</p>

3	 <p>Masses and springs at <a href="https://phet.colorado.edu">https://phet.colorado.edu</a></p>	<p><i>PhET Simulation of a spring-mass system:</i> A dynamic modelling tool used to visualize and analyze the oscillatory behavior of a spring-mass system, enabling students to examine energy transformations and kinematic variables in Simple Harmonic Motion (SHM).</p>
---	--	--

The ICT integration was evaluated using the standardized rubric provided in Table 5. To ensure inter-rater reliability, the evaluation results were independently assessed and cross-validated by 02 expert lecturers. The final consensus on the performance levels is illustrated in Figure 3.



**Figure 3. Scores distribution across ICT integration proficiency levels**

The experimental results indicate that after three iterative sessions of LP construction, a significant majority of students (75% or 15 out of 20) demonstrated measurable growth in their competence levels. Conversely, 25% (5 students) maintained a stagnant score, with their performance in the 3rd session remaining equal to their baseline in the first. This lack of progression may be attributed to a plateau in pedagogical content knowledge (PCK) or a specific challenge in exploiting interactive simulations tailored to the complex physics concept of the third lesson. A detailed, comprehensive analysis of the scores from the initial and final sessions is summarized in Table 10.

**Table 10. Statistical results of scores for attempts 1 and 3**

M (1st time)	SD (2nd time)	M (3rd time)	SD (time 3)	Mdiff	SDdiff
1.25	0.44	2.3	0.86	1.05	0.76

Statistical analysis indicates that the mean score for the third session was substantially higher than that of the first, demonstrating a significant improvement in student learning outcomes. The Wilcoxon Signed-Rank test confirms a statistically significant shift in performance between Time 1 and Time 3 ( $p < 0.001$ ). The standard deviation of differences (SDdiff) was 0.76, reflecting the variance caused by the subset of students whose scores remain static throughout the experiment.

Qualitative analysis of the students' lesson plan (LPs) reveals that their selection and pedagogical description of ICT integration remain suboptimal. Specifically, there was a noticeable lack of specialized physics software, such as video analysis tools (e.g, Tracker) or Computer-Based Laboratories (CBL). Furthermore, the functional descriptions of the chosen ICT tools often lack pedagogical alignment with the core physics content.

Regarding AI integration, despite receiving targeted guidance and scaffolding from the lecturer, students struggled to propose strategic AI-driven learning activities. Follow-up discussions confirmed a significant skill gap in leveraging AI to actively facilitate and organize student-centered learning. These identified competence gaps highlight critical areas for remediation in future coursework. Consequently, the rubric mapping the behavioral indicators of ICT competence proved to be an effective diagnostic tool, accurately reflecting the growth and limitations of pre-service physics teachers both pre-and post-intervention.

### 3. Conclusions

The research findings have systematically established and characterized the integration of ICT within lesson plans (LPs) aligned with the TPACK framework. Specifically, the granularity of descriptions across each domain –from TK, CK, PK to TCK, PCK, TPK, and TPACK - elucidates the strategic application of technology in teaching physics concepts, phenomena, laws, and processes. These applications are rigorously mapped to both subject-matter expertise and physics-specific pedagogical methodologies. With over 40 ICT-identified behavioral indicators for ICT application, these detailed descriptions serve as a critical framework for selecting and implementing ICT products that fulfill the TPACK requirements in physics education. Furthermore, the proposed assessment rubric has proven highly effective for the practical training of pre-service teachers. The pedagogical experiment demonstrates that training focused on TPACK-aligned ICT content empowers students to construct high-quality LPs more effectively. Utilizing these evaluation criteria provides essential scaffolding, allowing students to orient their instructional outputs and reflexively adjust their practices for superior pedagogical results. Ultimately, this research provides a scientific foundation for evolving teacher education curricula and suggests a roadmap for developing evaluation standards criteria within the broader context of educational digital transformation.

This study acknowledges several fundamental limitations, including the need for a more robust theoretical elaboration on the e-Delphi method and the psychometric properties of the assessment scale. Additionally, the experimental timeframe was relatively brief, and the study did not include a control group, which limits the ability to isolate the specific impact of the intervention. Furthermore, the assessment of the student competencies would benefit from a more diverse range of evaluative methodologies. These constraints provide a clear roadmap for future research, which will focus on refining the theoretical framework and optimizing experimental protocols to more accurately evaluate the ICT integration competence of pre-service physics teachers' lesson design.

**Acknowledgement.** This research is funded by Hanoi Pedagogical University 2 Foundation for Sciences and Technology Development under Grant Number HPU2.2025-UT-05.

### REFERENCES

- [1] Savage J, (2014). *Lesson Planning: Key concepts and skills for teachers*. Routledge, p.3.
- [2] Jamali A, (2014). The important role of the lesson plan on the educational achievement of Iranian EFL teachers' attitudes. *International Journal of Foreign Language Teaching and Research*, 3(5), 25-30.
- [3] Sehweil M, Mahmoud S & Jeidi M, (2022). The importance of the lesson plan elements in education and teachers' practices of them, *In Radical Solutions in Palestinian Higher Education: Research from An-Najah National University*, Springer, 93-94. [https://doi.org/10.1007/978-981-19-0101-0\\_8](https://doi.org/10.1007/978-981-19-0101-0_8).

- [4] Farhang Q, Hashemi A & Ghorianfar A, (2023). Lesson plan and its importance in the teaching process. *International Journal of Current Science Research and Review*, 6(08), 5901-5913. DOI: 10.47191/ijcsrr/V6-i8-57.
- [5] Ministry of Education and Training, (2020). Appendix 4, Official dispatch No. 5512/BGDĐT-GDTrH on *Building and organizing the implementation of the school's educational plans*.
- [6] Ngo TT, (2025). Implementing lesson plan development activities for high school physics in response to evaluation criteria. *TNU Journal of Science and Technology*, 230(04), 204-211. DOI: 10.34238/tnu-jst.
- [7] Kieu TL, Tran MN, Dang TTH, Doan TTH, Tran BH, Phan TT, Le QN, (2024). International experience in building teaching plans under the Blended learning model and recommendations for Vietnam. *Vietnam Journal of Educational Sciences*, 20(01), 73-80. DOI: 10.15625/2615-8957/12410111.
- [8] Roberts S, (2020). Blended learning lesson plans. New Readers Press. p. 3. [https://www.newreaderspress.com/site/Additional%20Resources/2020-12\\_NRP-BlendedLearning-LessonPlanSamples.pdf](https://www.newreaderspress.com/site/Additional%20Resources/2020-12_NRP-BlendedLearning-LessonPlanSamples.pdf).
- [9] Duong TMH, (2024). Designing the lesson plan for teaching writing in high school based on the TPACK model. *Vietnam Journal of Educational Sciences*, 20(8), 42-49. DOI: 10.15625/2615-8957/12410807.
- [10] Özdilek Z & Robeck EC, (2018). Enabling pre-service chemistry teachers' development of technological, pedagogical, and content knowledge (TPACK) through case-based lesson planning. *Journal of Uludag University Faculty of Education*, 32(1), 207-225. DOI: 10.19171/uefad.533233.
- [11] Jacob MFA, Fandim JV, Reis FJ, Hartvigsen J, Ferreira PH & Saragiotto BT, (2025). Defining core competencies for telehealth in healthcare higher education: A Delphi study. *Musculoskeletal Science and Practice*, 75, 1-8. DOI: 10.1016/j.msksp.2024.103244.
- [12] Barrios M, Guilera G, Nuño L & Gómez-Benito J, (2021). Consensus in the Delphi method: What makes a decision change?. *Technological Forecasting and Social Change*, 163, 1-10. DOI: 10.1016/j.techfore.2020.120484.
- [13] Wernke S & Zierer K, (2017). *Lesson planning: A forgotten area of competence (In German: Die Unterrichtsplanung: Ein in Vergessenheit geratener kompetenzbereich)*. Verlag Julius Klinkhardt, p. 11.
- [14] Trinh TG & Mai QK, (2019). Training teaching competence for teacher students of education universities based on a competence approach to meet the requirements of general education reforms. *Vietnam Journal of Educational Sciences*, 22, 34-39.
- [15] Pham TKA, (2020). Teaching competence framework for young teachers in high schools, as required by educational renewal. *HNUJ Journal of Science*, 65(1), 64-73. DOI: 10.18173/2354-1075.2020-0007.
- [16] Lyon LJ, (2015). Development of teaching expertise viewed through the Dreyfus model of skill acquisition. *Journal of the Scholarship of Teaching and Learning*, 15(1), 88-105. DOI: 10.14434/josotl.v15i1.12866.
- [17] Shulman LS, (1986). Knowledge growth in Teaching. *Educational Researcher*, 15(2), 4-14. DOI: 10.3102/0013189X015002004.
- [18] Mishra P & Koehler MJ, (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054. DOI: 10.1111/j.1467-9620.2006.00684.x.

- [19] Lyublinskaya I & Kaplon-Schilis A, (2022). Analysis of differences in the levels of TPACK: Unpacking performance indicators in the TPACK levels rubric. *Education Sciences*, 12(79), 1-20. DOI: 10.3390/educsci12020079.
- [20] Koenig J, Heine S, Jaeger-Biela D & Rothland M, (2024). ICT integration in teachers' lesson plans: A scoping review of empirical studies. *European Journal of Teacher Education*, 47(4), 821-849. DOI: 10.1080/02619768.2022.2138323.
- [21] Arsad B, Asham BJ, Saparuddin S, Nur Aisyah A, Muh A, (2023). The correlation between lesson planning and knowledge in order to use TPACK in school teachers in Makassar city. *Biology Teaching and Learning*, 6(2), 94-108. DOI: 10.35580/btl.v6i2.54039.
- [22] Kapici HO & Akcay H, (2023). Improving student teachers' TPACK self-efficacy through lesson planning practice in the virtual platform. *Educational Studies*, 49(1), 76-98. DOI: 10.1080/03055698.2020.1835610.
- [23] Ngo TT, Nguyen TPL, Nguyen AL & Le TQP, (2024). Transformation in the application of information technology in teaching high school physics. *HPU2 Journal of Science: Education Science*, 2(03), 248-248.
- [24] Fiolhais C & Trindade J, (1998). Use of computers in physics education. *New technologies for higher education: proceedings*, 103-115.
- [25] Esquembre F, (2002). Computers in physics education. *Computer Physics Communications*, 147(1-2), 13-18. DOI: 10.3991/ijep.v6i3.5899.
- [26] Srisawasdi N, (2012). The role of TPACK in physics classroom: case studies of preservice physics teachers. *Procedia-Social and Behavioral Sciences*, 46, 3235-3243. DOI: 10.1016/j.sbspro.2012.06.043.
- [27] Vaara R & Sasaki D, (2019). Teaching kinematic graphs in an undergraduate course using an active methodology mediated by video analysis. *Lumat: International Journal on Math, Science, and Technology Education*, 7(1), 1-26. DOI: 10.31129/Lumat.7.1.374.
- [28] Pham VH & Tran Q, (2024). Building interaction experiments on the screen through tracker video analysis software in teaching the “Kinematic” and “Oblication” sections—11th-grade physics to develop students' physics competence. *TNU Journal of Science and Technology*, 229(01/S), 149 - 156. DOI: 10.34238/tnu-jst.9272.
- [29] Le PT, Dang T, Lam TH & Vu VT, (2020). Integrating digital pedagogical methods in teaching and learning activities towards education 4.0. *Journal of Educational*, 481, 18-23.
- [30] Vieriu AM & Petrea G, (2025). The impact of artificial intelligence (AI) on students' academic development. *Education Sciences*, 15(3), 1-22. DOI: 10.3390/educsci15030343.
- [31] Vu XH, (2011). Vocational teachers' teaching capacities towards the performance approach. *Vietnam Journal of Educational Sciences*, 72, 41-44.
- [32] Duong HC & Le HC (2018). Developing primary education students' teaching competence. *Dong Thap University Journal of Science*, 30, 13-18.
- [33] Ngo TT, (2016). Blended learning models and their application in teaching electromagnetic induction in Grade 11. *Journal of Science of HNUE*, 61(6), 69-78. DOI: 10.18173/2354-1075.2016-0050.
- [34] Ministry of Education and Training, (2018). *Physics subject - General Education Program* issued with Circular 32/2018/TT-BGDĐT. p. 31-33.
- [35] Ministry of Education and Training, (2025). Issued Circular No. 02/2025/TT-BGDĐT stipulating *the Digital Competency Framework for learners*, p. 2-5.