Review Article

Technology Integration in Teaching: Applying TPACK Model for Vietnamese Universities

Pham Thi Thanh Hai[1,*], Nguyen Thi Huong Giang[1], Nguyen Thi Huyen[1], Pham Hong Hanh[1], Truong Ngoc Duong[2]

*¹Hanoi University of Science and Technology,
1 Dai Co Viet, Bach Khoa, Hai Ba Trung, Hanoi, Vietnam*
²Hoa Lu University, 385 Xuan Thanh, Ninh Nhat, Ninh Binh, Vietnam

Abstract: This research aims to synthesize international experiences in applying technology in teaching according to the TPACK model (Technological Pedagogical Content Knowledge), in order to draw lessons and apply them to Vietnamese universities. This article uses a theoretical research method, mainly synthesizing and analyzing texts from research papers published in large databases including Science Direct, Scopus, and Google Scholar, using keywords such as "TPACK" and "application of technology in teaching". To effectively apply technology, educational technologists have developed modern teaching frameworks, including the TPACK model, which combines three elements: i) Technological knowledge; ii) Pedagogical knowledge; and iii) Content knowledge. Teachers need to harmoniously integrate these three elements when applying the TPACK model. In Vietnam, there have been some recent studies on the TPACK model in universities; however, the number of studies is still limited. This research aims to synthesize and analyze relevant studies on the application of technology in teaching according to the TPACK model. International experiences serve as practical lessons for Vietnamese universities to adapt and apply appropriately to the TPACK model, integrating technology with content and pedagogical methods in teaching to meet current practical requirements.

Keywords: TPACK, teaching, technology application.

1. Introduction

Technology has paved the way for breakthrough changes in various aspects of life,

including higher education (HE) (N. T. B. Nguyet, 2021) [1]. In Vietnam, universities face many advantages and limitations when teaching and learning in the digital era. Research by N. T. H. Oanh (2022) has shown the level of impact of the 4.0 industrial revolution on Vietnamese HE [2].

_____
* Corresponding author.
 E-mail address: hai.phamthithanh@hust.edu.vn

In the context of digital transformation, teaching at the university requires additional aspects such as: i) Understanding Educational Technology: Instructors need to be well-versed in modern educational technologies and how to use them in teaching. This includes using computers, tablets, educational software, mobile applications, and new technologies like artificial intelligence and virtual reality; ii) Training and Support for Digital Skills: Instructors need training and support to develop digital skills such as creating digital content, managing online classrooms, conducting digital assessments, and interacting with students through online platforms; and iii) Building a Digital Learning Environment: Universities, instructors, and students need to develop a digital learning environment. This involves designing and managing a digital learning space, including creating digital educational content, managing online learning resources, and interacting with students through digital means.

Therefore, in the current digital transformation context, in addition to knowledge and skills, instructors need to be proficient in using technology in their teaching. This research aims to synthesize international experiences in applying technology in teaching in order to draw lessons and apply them to Vietnamese universities.

2. Literature Review

Many research findings confirm the relationship between technology, content, and pedagogical methods and the purposeful integration of these elements as the key to the success of improving the quality of education (Jing Lei, 2010; Mohamad Zaid Mohn Zin et al., 2013) [3, 4]. The reality shows that many instructors have good subject knowledge and pedagogical methods, but they lack sufficient knowledge about technology and how to integrate technology, content, and pedagogical methods in teaching (J. Hughes, 2005) [5]. Meanwhile, recent technological advancements have brought positive results in the field of education, such as creating more interactive

opportunities for teachers and learners, increasing student engagement and teaching effectiveness, enabling real-time collaboration among learners and teachers, and expanding the boundaries of the classroom by eliminating spatial and temporal constraints (R. S. Nickerson, P. P. Zodhiates, 2013) [6]. Other studies suggest that the application of technology in teaching can support and enhance learners' positive learning capabilities through the use of innovative information and communication technology (Z. T. Zhu et al., 2016; Abhipriya Roy, 2019) [7, 8]. The impact and role of educational technology have become even more evident during the outbreak of the COVID-19 pandemic, as the traditional learning environment has been significantly transformed, witnessing a shift towards online education in both general educational institutions and HE institutions worldwide.

To effectively apply technology in education, educational technologists have developed modern teaching frameworks, including the TPACK model (technological pedagogical content knowledge). This model is built upon Shulman's (1986) idea of pedagogical content knowledge and aims to define the essential knowledge that teachers need when integrating technology into the teaching process. It explains the complex and multifaceted nature of knowledge through the intersection of three components: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) [9]. To effectively implement the TPACK model, some studies worldwide have focused on pre-service teachers as the target audience to introduce and guide them in understanding the TPACK model (D. A. Schmidt et al., 2009) [10].

In Vietnam, there have been some recent studies on the TPACK model in HE, but the number of studies is still limited (N. N. Hieu, 2017; N. T. Dung, 2019; N. V. Loi, 2021) [11-13]. These studies have mainly focused on enhancing the understanding of the TPACK model in theoretical and practical aspects within the Vietnamese context. They assess the relevance and feasibility of a TPACK

framework for integrating technology in teaching andevaluate the learning outcomes of students using technology in specific subjects such as mathematics (T. M. Dung, 2022) or natural sciences (V. P. Lien, D. T. T. Phuong, 2023) [14, 15]. Some studies propose practical measurement scales based on the TPACK framework to assess teachers' technology integration competencies (N. T. Dung, 2023) [16]. Therefore, this research aims to synthesize and analyze relevant studies on technology integration in teaching according to the TPACK model. Additionally, the article identifies the aspects of current TPACK research conducted in Vietnam and determines areas that require further investigation.

3. Methodology

This study aims to synthesize international experiences on technology integration in teaching according to the TPACK model and draw lessons from these experiences to apply in Vietnamese universities. To achieve this objective, the study utilizes a theoretical research method (T. V. Minh, D. B. Lam, 2020) [17]. The theoretical research model for the literature review of the TPACK model includes, firstly, identifying the purpose of the research literature review; secondly, constructing the research overview and presenting it by grouping relevant issues for analysis and commentary; thirdly, through commentary, analyzing the published research results to identify issues that the researcher can continue to explore. The authors primarily employ text analysis methods from research works published in major databases, including Science Direct, Scopus, Google Scholar, etc., related to keywords such as "TPACK", "technology in teaching" and "technology integration in teaching". Firstly, the authors organize the literature and research findings published in scientific journals and reference books according to the content, including i) Iechnology integration in teaching; and ii) International research on the TPACK model in education (basic components of TPACK). Subsequently, the issues are

discussed based on the perspectives and trends of the research topic through the analysis of relevant documents, aiming to identify the development trends of technology integration in teaching according to the TPACK model in Vietnamese universities.

Thus, the article will analyze and answer the following research questions sequentially: i) How have international studies addressed technology integration in teaching according to the TPACK model? and ii) Evaluate the aspects of the current TPACK research conducted in Vietnam and identify the areas that require further investigation?

4. Results and Discussion

4.1. Technology Integration in Teaching

Technology plays an important role inHE. Many research outcomes have confirmed the relationship between technology, content, apedagogical methods, and the purposeful integration of these elements as the key to improving the quality of education. The reality shows that many teachers possess good subject knowledge and pedagogical methods but lack sufficient knowledge of technology and how to effectively combine technology, content, and pedagogical methods in teaching. Recent advancements in educational technology have brought positive results in the field of education, supporting both the teaching and learning processes and creating numerous opportunities for both teachers and students. These advancements include increased interaction and motivation for students, real-time collaboration between multiple learners and teachers, and the ability to overcome the limitations of physical space and time boundaries in the classroom.

Under the influence of the Fourth Industrial Revolution, the application of AI, Big Data, and IoT in smart schools has brought positive transformations in teaching, learning, and the management of the teaching process. Specifically, smart schools focus not only on stimulating creative thinking and caring for learners but also on considering the individual

differences and learning styles of their students. For example, the smart education system in Singapore places a high emphasis on technology. Their goal is to promote engaging learning experiences that meet the diverse needs of learners by utilizing innovative information and communication technology (Zhi-Ting Zhu et al., 2016) [7]. To achieve this, Singapore has created a learner-centric and personalized learning environment while establishing a national educational and lifelong learning architecture for educational institutions.

To optimize the functionality of technology and improve the quality of teaching, Sheninger and Kieschnick (2018) propose three reliable theoretical frameworks that educators can refer to: SAMR (Substitution - Augmentation - Modification - Redefinition), TPACK (Technological Pedagogical and Content Knowledge), and TIM (Technology Integration Matrix) [18]. Rogers (2018) suggests that TPACK is a suitable model for educators in any teaching context due to its practicality, simplicity, and high effectiveness [19].

4.2. International Research on the TPACK Model in Education

To effectively apply technology, educational technologists have developed modern teaching frameworks, including the TPACK model (abbreviation of "Technological Pedagogical Content Knowledge"). The TPACK model identifies the essential knowledge that educators need to possess when integrating technology into their teaching process, explaining the complex, multidimensional, and contextual nature of this knowledge.

The TPACK model is the intersection of three core knowledge domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). This model is built upon Shulman's concept of Pedagogical Content Knowledge (PCK).

The TPACK approach is based on assessing three independent types of knowledge: Content, Pedagogy, and Technology. Furthermore, this approach emphasizes the new forms of knowledge that emerge from the intersections

of these three knowledge types. For example, when considering Pedagogy (P) and Content (C) together, we have Pedagogical Content Knowledge (PCK), where Shulman's idea of pedagogical knowledge is the ability to apply teaching practices to specific content. Similarly, when considering Technology (T) and Content (C) together, we have Technological Content Knowledge (TCK), which refers to knowledge of the relationship between technology and content. At the intersection of Technology (T) and Pedagogy (P), we have Technological Pedagogical Knowledge (TPK), which emphasizes the existence, components, and capabilities of different technologies when they are used in the process of designing teaching and learning activities.
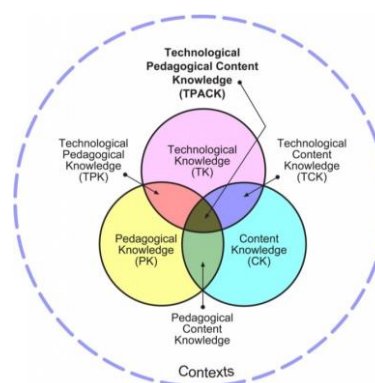

Figure 1. TPACK model
(source: www.tpack.org) [20].

At the intersection of all three components, we have Technological Pedagogical Content Knowledge (TPACK). Integrating technology truly involves understanding and coordinating the relationships among these three knowledge components. The ability to coordinate these relationships by a teacher represents a type of expertise that is different from, and even greater than, the expertise of a specialist in a subject matter field (such as a mathematician or historian), a technology expert (computer scientist), and a pedagogical expert (experienced educator). Efficiently integrating technology in teaching a specific topic/subject requires developing sensitivity to the dynamic

relationships and transitions among all three components: Content, Pedagogy, and Technology.

Finally, the TPACK framework describes seven domains of knowledge that teachers rely on for teaching with technology. This framework includes an eighth element labeled "contexts". This latter element has been inconsistently represented and defined in the literature, and has been considered interchangeably as both the contexts surrounding the application of the model (E. Brianza et al., 2022) [21]. Context is an important aspect when conducting educational science research (Tabak, 2013) [22]. However, context has received less attention in educational technology research (Garrison, 2003) [23]. In Vietnam, the context of digital transformation is mentioned in studies about TPACK by T. N. Duong, P. T. T. Hải (2024) [24]. When analyzing Context as a Domain of Knowledge, it is shown to be a quite complex construct, described by three levels (micro, meso, and macro) and three dimensions (social, resources, and content). Based on these findings, the authors discuss the structure of Context as a Domain of Knowledge and propose an extension of the TPACK framework to promote a more systematic approach to TPACK as a situated construct relevant to research on teacher expertise and teachers' professional development (Rosenberg & Koehler, 2015) [25].

In the TPACK framework, Technological Knowledge can be combined with:

i) Content Knowledge (CK) to form Technological Content Knowledge (TCK);

ii) Pedagogical Knowledge (PK) to form Technological Pedagogical Knowledge (TPK); and;

iii) Content Knowledge (CK) and Pedagogical Knowledge (PK) to form Technological Pedagogical Content Knowledge (TPACK).

Technological Pedagogical Knowledge - TPK

Technological Pedagogical Knowledge is the knowledge of the existence, components, and capabilities of different technologies when they are used in the process of setting up teaching and learning activities, and conversely, the understanding of how to effectively teach using specific technologies.

The relationship between technology and teaching is a complementary relationship, as the integration of technology into the teaching process enhances the effectiveness of teaching, and each type of teaching activity will require different technological requirements.

This may include knowledge of the necessary tools for a specific task, the ability to select tools, strategies for utilizing the features of the tools, knowledge of pedagogical strategies, and the ability to apply those strategies to the use of technologies.

For example, to monitor a class, class size, and grades, teachers can use learning management software, or create relationships between learners or between learners and teachers in the classroom through online discussion forums. Conversely, the emergence of new technologies, especially information technology, has brought about many changes in teaching activities, such as rich illustrations and the emergence of new learning environments such as online and blended learning.

In summary, a deep understanding of pedagogy will help teachers choose appropriate technologies, and the ability to use technology effectively will enrich teachers' pedagogical strategies.

Technological Content Knowledge - TCK

Technological Content Knowledge is the knowledge of how technological knowledge (TK) and Content Knowledge (CK) interact and complement each other.

Although the presentation of instructional content may be regulated and limited by technology, newer technologies are often more flexible and adaptable in directing the presentation process. Teachers should not only be familiar with the content they teach but also understand how technology can influence and change that content. Furthermore, learning a subject through the use of technology also helps learners gain knowledge about that technology.

For example, we can consider Geometer's Sketchpad software as a tool for teaching geometry. This allows learners to interact with shapes and forms, making it easier to construct standard geometric proofs. In this case, the software program simply follows what has been done before learning geometry. However, the computer program should do more than that. By allowing learners to "play" with geometric structures, it also changes the nature of self-directed learning of geometry-proofs constructed through building are a form of mathematical representation that cannot be achieved prior to using this technology.

Pedagogical Content Knowledge - PCK

Shulman (1986) upgraded the understanding of teachers' knowledge by introducing the concept of pedagogical content knowledge (PCK). He argued that the weakness of teachers lies in the separation of their subject matter knowledge and pedagogical knowledge, which are often seen as mutually exclusive domains. The practical result of this separation is the product of educational programs where teachers typically focus on either a subject matter or a dominant pedagogical approach. To explain this difference, Shulman proposed examining the relationship between these two domains by introducing the concept of PCK [9].

This knowledge includes knowing which teaching methods are suitable for specific content and, similarly, knowing how the components of the content can be organized for effective instruction. This knowledge is distinct from the knowledge of a subject matter expert and also differs from general pedagogical knowledge shared by teachers through principles. PCK involves the representation and formation of concepts, pedagogical techniques, understanding what makes concepts difficult or easy to learn, knowledge of learners' prior knowledge, and theories of cognitive psychology. It also encompasses knowledge of instructional strategies related to accurately presenting concepts, explaining learners' difficulties and misconceptions, and promoting meaningful understanding. It also includes knowledge of what learners bring to the learning situation, knowledge that can equip or hinder their functional performance in each learning task. This learner knowledge includes strategies, prior concepts, misconceptions that learners may have in a specific domain, and the transfer of prior knowledge.

PCK exists at the intersection of content and pedagogy. Therefore, it does not simply address the separate or joint evaluation of content and pedagogy but rather their combination, allowing for the transformation of content into effective pedagogical forms. PCK introduces the integration of content and pedagogy in understanding the specific aspects of organized, adaptable, and introduced topics during instruction. Shulman argued that knowledge of both subject matter and general pedagogical strategies is necessary but insufficient to capture the knowledge of an expert teacher. To describe the complexities of how teachers think about teaching a specific content, he proposed "pedagogical content knowledge" as the knowledge related to the process of instruction, including "ways of representing and formulating the subject that make it more accessible". Successful teachers must confront both content and pedagogy simultaneously by expressing "the most effective aspects of the content for its teachability" (Shulman, 1986) [9]. At the core of PCK is the transformation of subject matter for teaching. This happens when teachers interpret the subject matter, seek alternative ways to present it, and make it easily accessible to learners.

The concept of PCK has been expanded (and narrowed) by scholars following Shulman (Cochran, DeRuiter, King, 1993; J. V. Driel, W. Vearl, F. Janssen, 2001) [26, 27]. In fact, Shulman's initial description of teacher knowledge included more types (such as knowledge of curriculum, knowledge of instructional context, etc.). The complex issues arise from the fact that Shulman himself proposed multiple lists in different publications. The emphasis on PCK is based on Shulman's recognition that "pedagogical content

knowledge is special because it identifies the particular components of knowledge for teaching. It describes the combination of content and pedagogy into an understanding of how to organize, represent, and adapt topics, specific issues with differing concerns, and learners' capabilities". Furthermore, the emphasis on PCK is the integration with the work of many other scholars with recent educational innovations. Since its introduction in 1987, PCK has become a widely used and useful concept.

Figure 1 describes the knowledge of the teacher, with the intersection between the two circles referred to as Pedagogical Content Knowledge, serving as the link between content and pedagogy.

According to Shulman, this intersection contains "the most general conceptions of the topic, the most useful ways of representing the ideas, the most powerful reasoning, illustrations, examples, explanations, and demonstrations of the topics to be taught, that make the topic understandable and accessible to others".

The TPACK model (Koehler and Mishra, 2009) combines three elements: i) Technological Knowledge; ii) Pedagogical Knowledge; and iii) Content Knowledge. To effectively teach with technology tools, teachers need to harmoniously combine these three elements [28].

Candace Figg and Kamini Jaipal (2012) introduced the TPACK-in-Practice framework, derived from the PCK model (Shulman, 1986) and the TPACK model (Koehler & Mishra, 2009). Within the framework of the article, TPACK-in-Practice provides foundational knowledge to design lessons that create opportunities for technology-enhanced learning. Four design elements have been identified as useful for developing learning opportunities for teachers to develop TPACK-in-Practice. They include: i) Modeling types of technology-enhanced activities (learning with tools) to establish the context and purpose of tool use; ii) Integrating "pedagogical dialogue" into modeled lessons; iii) Developing specialized techniques for skill-based activities through brief

tool demonstrations; and iv) Applying TPACK-in-Practice to design teacher tasks [29].

A study by Lau Teng Lye (2013) examined the opportunities and challenges that a private HE institution in Malaysia faced when implementing the TPACK model in the teaching and learning process of its teachers. The study found that using the TPACK model would bring benefits to the teaching workforce in the process of educational development [30]. The survey questionnaire was designed based on the TPACK model specifications and used to identify aspects of technological knowledge, pedagogical knowledge, and content knowledge of the research subjects.

A study by Amade, Salasiah, Mahmud, Murni, Jabu, Baso, and Tahmir, Suradi (2020) presented an analysis of Technological Pedagogical Content Knowledge (TPACK) among teachers at Muhammadiyah Parepare University, Indonesia. The study showed that teachers' knowledge levels in technology, pedagogical methods, content knowledge, and TPACK were average. The faculty members could be classified as having a good overall level of TPACK knowledge, but improvement is needed to achieve better results by organizing more practical workshops or engaging in further learning. The results of the questionnaire indicated that teachers' knowledge levels in technology, pedagogical methods, content knowledge, and TPACK were average. They could be classified as having a good overall level of TPACK knowledge, but improvement is needed to achieve better results by organizing more practical workshops or engaging in further learning [31].

5. Recommendations for Research on the TPACK Model in Vietnamese Universities

Firstly, there should be more comparative studies on the application of the TPACK model between international contexts and Vietnam. Recommendations from the study conducted by Amade, Salasiah, and Mahmud, Murni and Jabu, Baso and Tahmir, Suradi (2020) on

assessing the level of implementation of the TPACK model in Indonesia are not only applicable to the situation in Indonesian universities but can also serve as practical international lessons for Vietnam. The survey results indicate that teachers' understanding of technology, pedagogical methods, content knowledge, and TPACK is at an average level, suggesting that teachers' competencies need to be improved to achieve better results through organizing more practical workshops or learning opportunities [31].

Secondly, continued research on applying the TPACK model in teaching various fields of study at different types of universities in Vietnam. In practice, there haven't been many studies on the TPACK model in Vietnamese universities, although many studies have been conducted in other countries. Some authors have researched the TPACK model in university teaching, such as N. N. Hieu (2017), N. T. Dung (2019), N. V. Loi (2021). The authors agree with the findings of these studies, emphasizing the need for theoretical and practical research on the TPACK model. Future studies should not only focus on the application of TPACK in English language teaching in Vietnam (N. V. Loi, 2021) but also extend to other subjects and different fields of study [11-13].

N. N. Hieu (2017) [11], T. N. Duong, P. T. T. Hai (2024) [24] suggest that the technology application and TPACK model in teaching and learning aim to innovate teaching methods and contribute to improving the effectiveness and quality of education. N. V. B. Hien and D. T. K. Thuong are mentioned about developing an innovative learning ecosystem in the context of digital transformation [32]. The article presents the main components and relationships between the components of the TPACK model which allows us to analyze key issues in educational technology. The model examines how content, pedagogy, and technology are related. Furthermore, the article highlights how the TPACK model can be used to design pedagogical strategies and provide insights into studying teachers' knowledge change regarding

successful technology-based teaching [11]. Based on survey data from 82 subjects, including secondary school teachers and experienced university teachers from different locations, the study aimed to assess the urgency and feasibility of a TPACK framework for integrating technology in teaching. The results show that the criteria in the measurement scale have relatively high urgency and feasibility (N. T. Dung, 2019) [12]. This is also a positive affirmation of the urgency and feasibility of implementing the TPACK model in Vietnamese universities.

Thirdly, research on applying the TPACK model in teacher training institutions in Vietnam is crucial, as future teachers need flexible technology integration skills to effectively teach in K-12 schools. Some research has been conducted on the application of TPACK in university education in specific fields, such as evaluating Information and Communications Technologies, (ICT) applying in the training students in Mathematics teaching at the Department of Mathematics and Computer Science, Ho Chi Minh City University of Education, based on the TPACK pedagogical content knowledge framework. The research results show the commonalities with the pedagogical recommendations of researchers worldwide while also pointing out differences that serve as a basis for proposing program improvements to better meet the requirements of the 2018 Mathematics curriculum in general education (T. M. Dung, 2022) [14]. Another study by N. V. Loi (2021) states that worldwide research has provided certain insights into the concept of TPACK as well as assessment and survey tools for TPACK. Therefore, it is necessary to conduct research that contributes to expanding the understanding of the TPACK model in both theoretical and practical aspects. The research has shown the application of TPACK in English language teaching in Vietnam, contributing to improving the effectiveness and quality of teaching and learning [13].

In the current era, technology is rapidly advancing. Enhancing ICT capabilities in teaching is a way to improve professional skills for

teachers in universities (Goradia, T., 2018) [33]. However, the reality of current teaching practices shows that most training programs mainly focus on equipping knowledge, technical skills, and pedagogical expertise, while neglecting technological knowledge and skills. Therefore, this research is necessary to comprehensively and holistically understand the ICT situation in teaching at Vietnamese universities. From there, appropriate proposals can be made to apply the TPACK model in teaching at universities to meet the requirements of modernization and enhance the quality of HE in the context of the strong development of the Fourth Industrial Revolution [5].

6. Conclusion

TPACK Model is increasingly being applied in HE today. Many studies have shown the relationship between technology, content, pedagogical methods, and their purposeful integration as the key to enhancing the quality of education (Jing Lei, 2010; Mohamad Zaid Mohn Zin et al., 2013) [3, 4]. In reality, many teachers possess strong subject knowledge and pedagogical methods but lack sufficient knowledge about technology and how to integrate it with content and pedagogical methods in teaching (Hughes, J., 2005) [5]. To effectively utilize technology, educational technologists have developed modern teaching theories, including the TPACK model (an acronym for "Technological Pedagogical Content Knowledge"). The TPACK model has been extensively researched in various countries worldwide. It combines three elements: i) Technological Knowledge; ii) Pedagogical Knowledge; and iii) Content Knowledge. To teach effectively with technological tools, teachers need to harmoniously integrate these three elements. Besides, the contextual factor has not been extensively studied and is considered to be interwoven with the surrounding context in the application of the TPACK model.

In Vietnam, there have been some recent studies on the TPACK model in HE, although the number of studies is still limited and focus on subjects teaching (N. T. Dung, 2019; N. V. Loi, 2021; T. M. Dung, 2022) [12-14]. This research aims to synthesize and analyze relevant studies on the TPACK model in HE. Additionally, three recommendations for further research on the TPACK model in Vietnamese universities include: i) There should be more comparative studies on the application of the TPACK model between international contexts and Vietnam; ii) Continued research on applying the TPACK model in teaching various fields of study at different types of universities in Vietnam; and iii) Research on applying the TPACK model in teacher training institutions in Vietnam is crucial, as future teachers need flexible technology integration skills to effectively teach in K-12 schools. International experiences provide practical lessons for Vietnamese universities to appropriately apply the TPACK model, integrating technology with content and pedagogical methods in teaching to meet current practical requirements.

Acknowledgements

References

[1] N. T. B. Nguyet, The Role of Applying Technological Advances in Teaching and Learning Activities, Journal of Industry and Trade, https://tapchicongthuong.vn/vai-tro-cua-viec-ung-dung-cong-nghe-trong-day-va-hoc-dai-hoc-hien-nay-82252.htm (accessed on: July 20th, 2021) (in Vietnamese).

[2] N. T. H. Oanh, Teaching and Learning in Higher Education in the Digital Age in Vietnam, Proceedings of 2nd Hanoi Forum on Pedagogical and Educational Sciences, Vietnam National University Press, Hanoi, 2022, pp. 156-166 (in Vietnamese).

[3] J. Lei, Quantity Versus Quality: A New Approach to Examine the Relationship between Technology use and Student Outcomes, British Journal of

Educational Technology, Vol. 41, No. 3, 2010, pp. 455-472, https://doi.org/ 10.1111/j.1467-8535.2009.00961.x.

[4] M. Z. M. Zin et al., Relationship between the Multimedia Technology and Education in Improving Learning Quality, Procedia - Social and Behavioral Sciences Vol. 90, 2013, pp. 351-355, https://doi.org/10.1016/j.sbspro.2013.07.102.

[5] J. Hughes, The Role of Teacher Knowledge and Learning Experiences in Forming Technology-Integrated Pedagogy, Journal of Technology and Teacher Education, Norfolk, VA: Society for Information Technology & Teacher Education, Vol. 13, No. 2, 2005, pp. 277-302.

[6] S. Raymond, Nickerson, P. P. Zodhiates, Technology in Education: Looking Toward 2020, Lawrence Erlbaurn Associates, Inc., Routledge Publishers, ISBN 0-8058-0214-2, 2013.

[7] Z. Z. Ting, Y. U. M. Hua, Riezebos, Peter, A Research Framework of Smart Education, Smart Learning Environments, Vol. 3, No. 4, 2016, pp. 1-17.

[8] A. Roy, Technology in Teaching and Learning, International Journal of Innovation Education and Research, Vol. 7, No. 4, 2019, pp. 414-422.

[9] S. S. Lee, Those who Understand: Knowledge Growth in Teaching, Educational Researcher, Vol. 15, No. 2, 1986, pp. 4-14.

[10] D. A. Schmidt et al., Technological Pedagogical Content Knowledge (TPACK) the Development and Validation of an Assessment Instrument for Preservice Teachers, Journal of Research on Technology in Education, Vol. 42, No. 2, 2009.

[11] N. N. Hieu, Applyling Technology and TPACK Model in Teaching, Vinh University Journal of Science, Vol. 46, No. 4B, 2017, pp. 18-26 (in Vietnamese).

[12] N. T. Dung, A Survey on the Necessity and Feasibility of the TPACK Framework for Integrating Technology in Teaching, Hue University Journal of Sciecne: Social Sciecnes and Humanities, Vol. 128, No. 6C, 2019, pp. 205, https://doi.org/10.26459/hueuni-jssh.v128i6C.5306 (in Vietnamese).

[13] N. V. Loi, Technological Pedagogical and Content Knowledge in Foreign Language Teaching: *A literature review*, Can Tho University Jourrnal of Sciecne, Vol. 57, No. 1C, 2021, pp. 186-195, https://doi.org/10.22144/ctu.jvn.2021.024 (in Vietnamese).

[14] T. M. Dung, Training Pre-service Teachers to Teach Mathematics with Information Technology: a View from the TPACK Framework, Ho Chi Minh City University of Education Journal of Science, Vol. 19, No. 2, 2022, pp. 201-212,

https://doi.org/10.54607/hcmue.js.19.2.3328 (in Vietnamese).

[15] V. P. Lien, D. T. T. Phuong, Applying the TPACK Model in Teaching Substances and Changes of Substances (Natural Science 6) through Designing E-book, Journal of Education, Vol. 23, No. 7, 2023, pp. 133-138 (in Vietnamese).

[16] N. T. Dung, Proposing a Practice Scale Based on the TPACK Framework for Competence Assessment - Technology Integration in Teaching, Journal of Education, Vol. 23, No. 08, 2023, pp. 34-39 (in Vietnamese).

[17] T. V. Minh, D. B. Lam, Educational Science Researching Methodology, Vietnam National University Hanoi Publisher, 2020 (in Vietnamese).

[18] E. Sheninger, W. Kieschnick, Integrating Technology into Instructional Practice, http://leadered.com/pdf/IntegratingTechnologyInstructionalPractice.pdf/, 2018 (accessed on: July 20th, 2021).

[19] M. Roger, The TPACK Framework Explained. https://www.schoology.com/blog/tpack-frameworkexplained/, 2018 (accessed on: July 20th, 2021)

[20] http://www.tpack.org (accessed on: July 20th, 2021).

[21] E. Brianza, M. Schmid, J. Tondeur, D. Petko, Situating TPACK: A Systematic Literature Review of Context as a Domain of Knowledge, Contemporary Issues in Technology and Teacher Education, Vol. 22, No. 4, 2022, pp. 707-753.

[22] I. Tabak, Lights, Camera, Learn: When the Set is as Important as the Actors, In R. Luckin, S. Puntambekar, P. Goodyear, B. L. Grabowski, J. Underwood, N. Winters (Eds.), Handbook of Design in Educational Technology, New York, NY: Routledge, 2013, pp. 397-405.

[23] M. J. Garrison, Expanding the Notion of Social Context in Educational Technology Research: Notes from the Field, Welsh Journal of Education, Vol. 12, No. 1, 2023, pp. 26-39.

[24] T. N. Duong, P. T. T. Hai, Primary School Teacher Training in the Context of Digital Transformation - TPACK Model Approach, Journal of Education, Vol. 24, No. 8, 2024, pp. 40-45 (in Vietnamese).

[25] J. M. Rosenberg, M. J. Koehler, Context and Technological Pedagogical Content Knowledge (TPACK): A Systematic Review, Journal of Research on Technology in Education, Vol. 47, No. 3, 2015, pp. 186-210.

[26] K. F. Cochran, J. A. DeRuiter, R. A. King, Pedagogical Con-tent Knowing: An Integrative

Model for Teacher Preparation, Journal of Teacher Education, Vol. 44, No. 4, 1993, pp. 263-272.

[27] J. V. Driel, W. Veal, F. Janssen, Pedagogical Content Knowledge: An Integrative Component within the Knowledge Base for Teaching, Teaching and Teacher Education, Vol. 17, No. 8, 2001, pp. 979-986.

[28] M. J. Koehler, P. Mishra, What is Technological Pedagogical Content Knowledge? Contemporary Issues in Technology and Teacher Education, Vol. 9, No. 1, 2009, pp. 60-70.

[29] Figg, Candace; JAIPAL, Kamini, TPACK-in-Practice: Developing 21st Century Teacher Knowledge, In: Society for Information Technology & Teacher Education International Conference, Association for the Advancement of Computing in Education (AACE), 2012, pp. 4683-4689.

[30] L. T. Lye, Opportunities and Challenges Faced by Private Higher Education Institution using the

TPACK Model in Malaysia, Procedia - Social and Behavioral Sciences, Vol. 91, 2013, pp. 294-305.

[31] Amade, Salasiah, Mahmud, Murni, Jabu, Baso, Tahmir, Suradi, TPACK Model Based Instruction in Teaching Writing: An Analysis on TPACK Literacy, Iternational Journal of Language Education, Vol. 4, No. 1, 2020, pp. 129-140.

[32] N. V. B. Hien, D. T, K, Thuong, Developing Hanoi's Innovative Learning Ecosystem in the Context of Digital Transformation, Proceedings of 2nd Hanoi Forum on Pedagogical and Educational Sciences, Vietnam National University Press, Hanoi, 2022, pp. 188-198 (in Vietnamese).

[33] T. Goradia, Role of Educational Technologies Utilizing the TPACK Framework and 21st Century Pedagogies: Academics' Perspectives, Vol. 6, No. 3, 2018, pp. 43-61.