Education

Proposed solutions for managing teaching and learning activities in natural sciences using the TPACK model approach in junior high schools in Dong Nai city

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Abstract
This study aims to analyze the current situation and propose solutions for managing the teaching and learning of Natural Sciences using the TPACK model approach in junior high schools in Dong Nai city, in the context of implementing the 2018 General Education Program and digital transformation in education. The study uses a mixed-methods approach, combining quantitative surveys with 189 administrators and teachers and semi-structured interviews with 13 subjects to clarify practical issues. Data were processed using descriptive statistics and content analysis, based on the TPACK theoretical framework and the quality assurance approach (CIPO). The research results show that the teaching and learning of Natural Sciences has shifted towards competency development and integrated teaching; however, the level of technology integration remains limited, mainly at the support level. Management remains administrative, lacking mechanisms to promote the development of TPACK competencies for teachers, especially in professional development and assessment. These limitations reflect the gap between the demands for educational innovation and the capacity for implementation at the grassroots level. Based on the research results, this paper proposes a direction for building a synchronized management system, linked to teacher competency development, innovation in professional activities, and integration of technology throughout the teaching and learning process. The research has both theoretical and practical significance, contributing to supplementing the approach to teaching and learning management according to the TPACK model in the context of modern education.

Keywords: Teaching and learning management, Natural science subject, TPACK model, Junior high school, Dong Nai city

1. Introduction

In the context of strong globalization and digital transformation, Vietnamese general education faces the requirement for fundamental innovation in terms of objectives, content, and methods of organizing teaching and learning to develop the qualities and competencies of learners. Resolution No. 29-NQ/TW of the Central Committee (2013) [7] clearly affirmed the direction of shifting from an education system heavily focused on knowledge transmission to one that comprehensively develops students' abilities and qualities. Based on this, the 2018 General Education Program was implemented, in which the Natural Science subject at the lower secondary level was designed in an interdisciplinary integrated approach (Physics, Chemistry, Biology), aiming to help students develop scientific thinking, problem-solving skills, and the ability to apply knowledge to practice (Ministry of Education and Training, 2018) [22].

However, the implementation of integrated teaching of Natural Science in practice poses many challenges for teachers and school administrators. Recent studies show that teachers still face difficulties in designing integrated lessons, organizing competency-oriented learning activities, and effectively using technology in teaching (Le Thanh Huy & Phung Viet Hai, 2019; Nguyen Phuong Lan, 2025) [17, 18]. Furthermore, the management of teaching activities in many secondary schools has not kept pace with the demands of innovation, remaining administrative, lacking professional support mechanisms, and not being linked to ensuring educational quality (Nguyen Duc Chinh, 2019; Tran Phuong Thao, 2026) [6, 27].

In this context, integrating information technology into teaching has become an inevitable trend to improve educational effectiveness. The TPACK (Technological Pedagogical Content Knowledge) model is considered one of the important theoretical frameworks that helps teachers harmoniously combine professional knowledge, pedagogical methods, and technology in the teaching process. Numerous international studies have shown that developing TPACK competencies in teachers has a positive impact on teaching quality, especially in STEM fields (Chai, 2019; Du *et al*., 2019) [5, 10]. Simultaneously, teacher professional development programs based on TPACK also contribute to improving the ability to design and organize integrated learning activities, in line with current educational reform requirements (Capps *et al*., 2012; Desimone, 2009) [2, 8].

However, in Vietnam in general and Dong Nai city in particular, the application of the TPACK model in managing teaching activities in Natural Sciences at the lower secondary level remains a significant research gap. Existing studies mainly focus on developing teachers' teaching competencies or organizing integrated teaching activities, while the

management aspect – especially management using an integrated approach of technology, methods, and content – has not been systematically studied (Nguyen Ngoc Quy, 2020; Le Thi Anh Tu, 2019) [26, 29]. This leads to the fact that many schools have not yet developed appropriate management strategies to support teachers in effectively implementing teaching according to the TPACK model.

On the other hand, Dong Nai city is one of the localities with a rapid urbanization rate, with an increasing demand for high-quality human resources. This places an urgent need on general education, especially at the lower secondary level – the foundational stage in forming scientific competencies and career orientation for students. However, in practice, the teaching of Natural Sciences in many schools in the province still has limitations such as: inflexible lesson planning, assessment activities not linked to competency development, and especially the application of technology in teaching is still largely superficial (Ministry of Education and Training, 2023; Nguyen Duc Huan, 2023) [25, 16].

From an educational management perspective, the quality assurance model approach (CIPO – Context, Input, Process, Output) shows that teaching effectiveness depends not only on the individual competence of teachers but is also strongly influenced by management factors such as policies, resources, learning environment, and professional support mechanisms (Nguyen Duc Chinh, 2019) [6]. Therefore, proposing solutions for managing teaching activities in Natural Sciences using the TPACK approach needs to be considered comprehensively, linked to the specific context of the locality and the national education reform orientation.

In addition, studies on teacher professional development also emphasize the role of continuous professional development programs that are highly practical and linked to teachers' needs in improving integrated teaching skills and technology application (Carlson & Gadio, 2002; Groothuijsen *et al*., 2019) [3, 13]. However, without guidance and support from school administrators, these activities are unlikely to achieve sustainable effectiveness. This highlights the need to build a comprehensive management solution system, in which the TPACK model serves as the theoretical foundation and practical guide.

From the above analysis, it can be seen that, although there have been many studies on teaching Natural Sciences and developing teacher competencies, there is still a lack of research approaching the issue from a management perspective using the TPACK model, especially in the context of implementing the 2018 General Education Program in specific localities such as Dong Nai city. This gap necessitates in-depth research to propose appropriate management solutions, contributing to improving the effectiveness of teaching Natural Sciences and meeting the requirements of educational reform.

Therefore, the topic "Proposing solutions for managing teaching and learning activities in Natural Sciences using the TPACK model approach in junior high schools in Dong Nai city" was undertaken to clarify the theoretical and practical basis of the issue, and to propose feasible management solutions suitable to the local context. The research is not only significant theoretically in supplementing the TPACK model approach to teaching and learning management, but also has practical value in supporting educational managers and teachers to improve the quality of teaching and learning, meeting the requirements of educational development in the digital age.

2. Literature review

2.1. Evaluation of research results

In recent years, research on teaching Natural Sciences and managing teaching and learning activities oriented towards competency development has attracted considerable attention from the academic community both domestically and internationally. The works can be categorized into three main approaches: (i) research on teacher competency development and innovation in science teaching; (ii) research on the application of technology and the TPACK model; and (iii) research on managing teaching activities using a quality assurance approach.

Firstly, international studies have provided important theoretical and practical foundations for teacher professional development in science teaching. Capps *et al*. (2012) [2] showed that inquiry-based learning teacher training programs have a positive impact on improving the capacity to organize science teaching, but effectiveness strongly depends on the degree of connection between theory and practice. Similarly, Desimone (2009) [8] emphasized that professional development programs are only truly effective when ensuring core elements such as relevant content, continuity, active teacher participation, and organizational support. Other empirical studies also demonstrate that long-term training, linked to the practical context of the classroom, significantly improves the quality of science teaching (Dori & Herscovitz, 2005; Groothuijsen *et al*., 2019) [9, 13].

In the context of STEM education, the integration of interdisciplinary knowledge has become an inevitable trend. Cavlazoglu and Stuessy (2017) [4] pointed out that changes in teachers' perceptions of STEM are directly related to the ability to connect interdisciplinary knowledge in teaching. Du *et al*. (2019) [10] also affirmed that STEM professional development programs have a positive impact on teacher quality, especially in designing integrated learning activities. These results are consistent with the integrated teaching orientation of Natural Sciences in the 2018 General Education Program of Vietnam (Ministry of Education and Training, 2018) [22].

Secondly, regarding the application of technology in teaching, the TPACK model has been identified as an important theoretical framework. Chai (2019) [5] synthesized studies and showed that TPACK not only helps teachers integrate technology effectively but also supports the design of lessons suitable to the specific content and teaching methods. Carlson and Gadio (2002) [3] early on emphasized the role of teacher training in the use of technology as a decisive factor in the success of educational innovation. Furthermore, Ertmer *et al*. (2007) [11] pointed out that the integration of technology needs to be accompanied by a change in teachers' pedagogical beliefs; otherwise, it will remain merely a formality.

Thirdly, from an educational management perspective, many studies have addressed the role of school management in improving the quality of teaching and learning. Nguyen Duc Chinh (2019) [6] emphasized that management based on a quality assurance approach needs to be implemented systematically, encompassing inputs, processes, and outputs (CIPO). Domestic studies such as those by Nguyen Minh Tuan (2018) [31], Nguyen Ngoc Quy (2020) [26], and Le Thi Anh Tu (2019) [29] have analyzed the current state of science teaching management and proposed several solutions such as innovating teaching plans, strengthening assessment and evaluation, and developing the teaching staff. However, these solutions are mainly traditional and not closely linked to modern theoretical models such as TPACK.

In addition, recent studies in Vietnam have more clearly reflected the current state of science teaching implementation according to the 2018 General Education Program. Nguyen Phuong Lan (2025) [18] pointed out that science teaching activities still face many difficulties because teachers are not yet familiar with integrated teaching and lack the capacity to use technology. Tran Phuong Thao (2026) [27] also showed that teaching management in some localities is still administrative in nature and lacks professional support. At the same time, studies on teacher professional development (Vu Cam Tu & Nguyen Yen Chi, 2024) [30] emphasize the need for training models linked to practice, such as lesson study (Nguyen Thi Thu Thuy *et al*., 2019) [28].

Overall, existing research has achieved significant results in clarifying the role of integrated teaching, teacher competency development, and technology application in science education. Simultaneously, these studies have also begun to address the role of educational management in supporting teaching innovation. However, these research directions remain fragmented, lacking integration between content, methods, and technology within a unified management framework.

2.2. Gaps and research directions

Firstly, most studies on integrated teaching and learning focus on developing teachers' individual competencies, while the role of school management in promoting and maintaining these competencies has not been fully studied. Current research has not clarified how to integrate integrated teaching and learning into management activities such as planning, organizing, directing, and evaluating. This leads to the implementation of TPACK in practice being spontaneous and lacking a systematic approach.

Secondly, studies on the management of science education in Vietnam mainly focus on proposing general measures, not based on a modern theoretical framework and not linked to the requirements of digital transformation in education. Meanwhile, according to Carlson and Gadio (2002) [3] and Chai (2019) [5], integrating technology into teaching should be considered a systematic process requiring support from management levels.

Thirdly, there is a lack of empirical studies linked to the specific context of each locality. Each locality has its own characteristics in terms of socio-economic conditions, infrastructure, and teaching staff, therefore requiring appropriate management solutions. For Dong Nai city, a rapidly developing locality, there are currently no in-depth studies on the management of science education using the TPACK approach.

Fourthly, existing studies have not fully integrated the quality assurance approach (CIPO) and the TPACK model. Meanwhile, integrating these two approaches could create a comprehensive theoretical framework that ensures the systematic nature of educational management while meeting the requirements of teaching innovation in the digital age (Nguyen Duc Chinh, 2019) [6].

Based on these gaps, this research focuses on: (i) building a theoretical basis for managing teaching activities in Natural Sciences using the TPACK approach; (ii) analyzing the current state of teaching management in junior high schools in Dong Nai city; and (iii) proposing a system of management solutions that are synchronized, feasible, and aligned with the local context and educational innovation orientation. Through this, the research not only contributes to supplementing the theory of educational management in the direction of technology integration, but also provides a practical basis for improving the quality of teaching Natural Sciences in the current period.

3. Research methods

The research was conducted using a mixed-methods approach, combining quantitative and qualitative methods to ensure the comprehensiveness and reliability of the results. The research design was based on a descriptive model – analyzing the current situation combined with proposing solutions, suitable for the specifics of educational management research.

Regarding the quantitative method, the research conducted a survey using questionnaires with a total of 189 participants, including management staff (principals, vice-principals), heads of subject departments, and teachers of Natural Sciences at junior high schools in Dong Nai city. The survey sample was selected using a controlled convenience sampling method, ensuring diversity in job positions, teaching experience, and school conditions. The survey tool was designed based on the TPACK theoretical framework and a quality assurance model (CIPO) management approach, including groups of criteria related to: (i) lesson planning; (ii) implementation; (iii) professional guidance; and (iv) monitoring and evaluation of teaching activities in Natural Sciences.

A 5-point Likert scale was used to measure the level of agreement of participants, with levels from 1 (Strongly disagree/not agree) to 5 (Strongly agree/very agree). The collected data was processed using descriptive statistical methods (mean value, standard deviation) to reflect the trends and levels of evaluation of the survey subjects. Simultaneously, the study conducted reliability testing of the scale through Cronbach's Alpha coefficient to ensure the internal consistency of the observed variables

Regarding qualitative methods, the study used semi-structured interviews with 13 subjects (coded from PV01 to PV13), including administrators and teachers experienced in teaching and managing Natural Sciences. The interviews focused on clarifying the difficulties, advantages, and practical needs in implementing teaching using the TPACK approach, as well as evaluating the effectiveness of current management activities. Qualitative data was analyzed using thematic coding, thereby supplementing and deepening the quantitative results.

In addition, the study also used document analysis to synthesize the theoretical basis and related studies, and applied expert methods to build and refine the proposed management solutions. The combination of these methods contributes to ensuring the scientific rigor, objectivity, and practical value of the research.

4. Research results

4.1. Current status of natural science lesson planning using the TPACK approach

A survey of 189 administrators and teachers shows that Natural Science lesson planning has undergone certain changes towards an integrated approach; however, the level of integration of technology and TPACK thinking is still uneven.

Table 1: Current status of lesson planning using TPACK

No.	Survey content	Cronbach's alpha	SD	Mean
1	Integrated interdisciplinary lesson plans (Physics – Chemistry – Biology)	0.82	0.71	3.78
2	Lesson plans incorporating technology support	0.79	0.76	3.52
3	Lesson plans linked to student competency development	0.85	0.68	3.91
4	Lesson plans oriented towards applying the TPACK model	0.77	0.82	3.34
5	Lesson plans flexible according to actual conditions	0.81	0.74	3.63
6	Participation of subject departments in lesson plan development	0.83	0.69	3.85

The results show that the average value ranges from 3.34 to 3.91, reflecting a moderately good level of implementation. The content with the highest score is "related to the development of students' competencies" (Mean = 3.91), indicating that the orientation of the 2018 General Education Program has been clearly understood (Ministry of Education and Training, 2018) [22]. However, the content "applying the TPACK model" has the lowest score (Mean = 3.34), showing that teachers still face difficulties in simultaneously integrating the three elements of technology, pedagogy, and content. This result is consistent with Chai's (2019) [5] observation that TPACK competency does not develop spontaneously but needs systematic training. "We have a plan for integrated teaching, but the integration of technology into lessons is still hesitant and not truly effective" (PV09).

4.2. Current status of teaching and learning in natural sciences according to the TPACK model

The organization of teaching and learning activities is the decisive factor in the quality of the practical implementation of the TPACK model. Survey results show a clear difference between theoretical orientation and classroom practice.

Table 2: Current status of teaching and learning organization according to TPACK

No.	Survey contents	Cronbach's alpha	SD	Mean
1	Organization of integrated thematic teaching and learning	0.84	0.72	3.76
2	Use of technology in teaching	0.78	0.83	3.41
3	Application of active learning methods	0.86	0.69	3.88
4	Organization of science-based experiential activities	0.80	0.77	3.57
5	Integration of technology with teaching methods	0.76	0.85	3.29
6	Ability to flexibly adjust teaching and learning activities	0.82	0.73	3.69
7	Level of active student participation	0.83	0.71	3.81

The average score indicates a low level of implementation, especially in the indicator "integrating technology with teaching methods" (Mean = 3.29). This reflects the gap between using technology alone and integrating technology according to TPACK. According to Ertmer *et al*. (2007) [11], effective technology use depends on the pedagogical beliefs of teachers. "We use PowerPoint or video, but we don't know how to systematically combine technology with teaching methods" (PV02). Conversely, active teaching activities (Mean = 3.88) and student participation (Mean = 3.81) reached a fairly good level, showing a positive shift towards learner-centered learning.

4.3. Current status of professional guidance and TPACK competency development for teachers

Professional guidance plays an important intermediary role between policy and teaching practice. The survey results show that the level of support is limited.

Table 3: Current status of professional guidance according to TPACK

No.	Survey content	Cronbach's alpha	SD	Mean
1	Directing the innovation of teaching methods	0.85	0.70	3.82
2	Organizing TPACK competency training	0.78	0.88	3.21
3	Supporting teachers in applying technology	0.80	0.81	3.36
4	Organizing professional development activities based on lesson study	0.84	0.73	3.75
5	Encouraging innovation in teaching	0.83	0.72	3.79
6	Building a professional learning community	0.79	0.85	3.33

The indicator "TPACK competency development" scored the lowest (Mean = 3.21), indicating that this activity has not been systematically implemented. This is consistent with the research of Carlson and Gadio (2002) [3] which emphasized that teacher training in technology requires a long-term strategy. "We organized training, but it was mainly introductory, not deeply focused on practical application" (PV01). Meanwhile, professional development activities following lesson study (Mean = 3.75) had a positive effect, consistent with the proposal of Nguyen Thi Thu Thuy *et al*. (2019) [28].

4.4. Current status of testing and evaluation of teaching activities according to the TPACK approach

Testing and evaluation activities are decisive factors in maintaining and improving the quality of teaching and learning. However, the survey results show that this is a stage with many limitations.

Table 4: Current status of testing and evaluation according to TPACK

No.	Survey Content	Cronbach's Alpha	SD	Mean
1	Assessment based on student competencies	0.86	0.69	3.87
2	Assessment of teacher teaching activities	0.82	0.74	3.62
3	Using technology in assessment	0.77	0.88	3.18
4	Providing timely feedback to teachers	0.83	0.76	3.55
5	Combining qualitative and quantitative assessment	0.84	0.72	3.73
6	Assessment based on TPACK criteria	0.75	0.91	3.05

The results show that "assessment based on TPACK" received the lowest score (Mean = 3.05), clearly reflecting the gap in the development of modern assessment criteria. This indicates that education management has not kept pace with the requirements of digital transformation and technology integration. "Assessment is still mainly based on records and teaching hours, lacking specific criteria for technology application" (PV11). According to Nguyen Duc Chinh (2019) [6], assessment needs to be linked to comprehensive quality assurance; however, in reality, its application remains limited.

Overall, the research results show that: Science teaching activities have shifted towards competency development but have not effectively integrated TPACK. The use of technology is still supportive, not reaching a deep level of integration. Management lacks a systematic approach and is not linked to modern theoretical models. Training and assessment activities based on TPACK are the biggest weaknesses. These results accurately reflect the trends observed in previous studies (Chai, 2019; Du *et al*., 2019) [5, 10], and also indicate the urgent need to develop systematic management solutions that are appropriate to the local context.

5. Discussion

The research results show that the overall management of teaching and learning activities in Natural Sciences at junior high schools in Dong Nai city is in the process of shifting towards competency-based development, but has not yet reached the level of deep integration according to the TPACK model. This reflects a common reality in the context of educational reform, where a significant gap still exists between policy and practice.

Firstly, regarding the aspect of lesson planning, the results show that teachers have initially approached integrated thinking and competency-based development, in line with the requirements of the 2018 General Education Program (Ministry of Education and Training, 2018) [22]. However, "the integration of technology into teaching plans is still limited in terms of method and content" (PV13). This is consistent with Chai's (2019) [5] assessment that TPACK competence is not just a sum of three components (content – pedagogy – technology), but requires systematic integration, formed through long-term professional development. The low average score of the "TPACK application" indicator shows that: "Teachers are still in the 'initial approach' stage, not yet transformed into practical competence" (PV03).

Secondly, in teaching organization, although active teaching methods have been implemented quite effectively, the integration of technology with teaching methods is still largely superficial. This shows that technology still mainly plays a supporting role in presenting content, rather than becoming a constituent component of the teaching process. This result is consistent with the research of Ertmer *et al*. (2007) [11], when the authors pointed out that the biggest barrier in integrating technology lies not in the skills of using it, but in the changing pedagogical beliefs of teachers. At the same time, this also reflects a reality noted in STEM studies, that connecting knowledge components in teaching requires a profound transformation in professional awareness and practice (Cavlazoglu & Stuessy, 2017) [4]. "Many administrators and teachers have made significant changes in their awareness of the need for change in teaching, but the results achieved are not yet high" (PV05).

Thirdly, from a management perspective, the research results show that professional guidance activities have undergone positive changes, especially in promoting innovation in teaching methods and professional activities. However, "the development of TPACK capacity for teachers has not yet received adequate attention" (PV12). This shows that school management has not truly played a "constructive" role in the innovation process, but still leans towards administrative functions. According to Desimone (2009) [8], professional development programs are only effective when they are systematically designed, linked to practical needs, and have continuous support from the organization. "The lack of in-depth training programs on TPACK in Dong Nai shows a gap in the workforce development strategy" (PV07).

Furthermore, research results also show that assessment activities have not kept pace with the demands of innovation. "Although competency-based assessment of students has been implemented relatively well, the use of technology and TPACK criteria in assessment is still very limited" (PV06). This reflects a lack of synchronization in the management system, as the planning – organization – direction – inspection stages have not been integrated according to a unified logic. According to Nguyen Duc Chinh (2019) [6], management using a quality assurance approach requires close linkage between input, process, and output elements. However, research results show that this model has not been fully applied in practice.

Notably, qualitative results from interviews have further clarified the difficulties faced by teachers and administrators. Some opinions suggest that the integration of technology is still largely a "trend," lacking specific guidance and not suitable for the school's infrastructure. This assessment aligns with the views of Carlson and Gadio (2002) [3], who emphasized that the application of technology in education is only effective when accompanied by investment in infrastructure and human resource training. Simultaneously, opinions also highlight the urgent need for practice-based training models, such as lesson studies, which have proven effective in developing integrated teaching competencies (Nguyen Thi Thu Thuy *et al*., 2019) [28]. From an international comparative perspective, these research results are consistent with the general trend in studies on STEM and TPACK education. Du *et al*. (2019) [10] pointed out that improving teacher quality through integrated professional development programs is a key factor in improving teaching quality. Looi *et al*. (2018) [19] also emphasized the role of context-based professional development models in promoting curriculum innovation. These results show that applying the TPACK model in teaching management is not only a theoretical requirement, but also an inevitable trend in modern educational practice.

In short, the research results have clarified a paradox: while the direction of educational innovation has been clearly established, the capacity for implementation – especially at the school management level – remains limited. This necessitates the development of a comprehensive management solution system, in which the TPACK model is not only considered a teaching support tool, but is integrated into the entire educational management process. This is a crucial basis for the research and proposed solutions in the following section, aimed at improving the effectiveness of teaching science subjects in junior high schools in Dong Nai city in the context of current digital transformation.

6. Conclusion

This study has clarified the current state of management of teaching and learning activities in Natural Sciences at junior high schools in Dong Nai city from the perspective of the TPACK model, thereby providing empirical evidence on the degree of shift from traditional teaching to technology-integrated teaching. The results show that although schools have initially implemented competency-based teaching in accordance with the 2018 General Education Program, the integration of technology in teaching and management is still limited, lacking systematicity and not reaching the level of deep integration according to the TPACK framework. Theoretically, the study contributes to supplementing the approach to teaching management in the direction of integrating content – methods – technology, and affirms the role of the TPACK model as an important reference framework in the context of digital transformation in education. In practical terms, the results indicate that the main limitations lie in the teachers' implementation capacity, the lack of coordination in management, and the absence of an evaluation mechanism suitable for the requirements of innovation. However, the study still has some limitations, such as the limited scope of the survey to a single locality and the lack of advanced quantitative analysis. Therefore, further studies need to expand the sample size and incorporate more in-depth analytical models to test the effectiveness of the proposed management solutions, contributing to improving the quality of teaching and learning in the context of modern education.

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