

# Effectiveness of integrated theoretical and practical teaching strategies in vehicle digital control course

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## Abstract

This investigates how the integration of theoretical and practical teaching strategies in the Vehicle Digital Control course influence student participation, comprehension of theoretical knowledge, and practical application, while also identifying key challenges and proposing targeted improvements. A qualitative descriptive research design was employed. Data were gathered through in-depth, semi-structured interviews with three (3) teachers and 10 students engaged with the integrated teaching strategy during the 2023–2024 academic year. Thematic analysis was used to interpret patterns in perceptions and experiences. The findings indicate that the theoretical and practical teaching strategies significantly enhance student engagement and the ability to apply theoretical concepts in real-world contexts. However, the study also uncovered critical barriers: limited access to functional equipment, difficulties in linking theory to practice, and inadequate teacher training in hands-on skills. Participants suggested greater investment in teaching resources, more practical teacher development programs, and the adoption of innovative methods such as project-based learning and simulation tools. The results guide the construction of an integrated Theoretical and Practical Teaching Strategies (TPTS) framework that blends essential elements, resource investment, teacher development, and creative instructional design, with active learning strategies and instant feedback. This framework confronts the key challenges identified, providing a scalable and flexible model for improving student engagement, knowledge retention, and practical skills in numerous technical courses.

**Keywords:** *integrated teaching strategies, vocational STEM education, theory–practice integration, vehicle digital control, student engagement, hands-on learning*

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## 1. Introduction

Education, particularly vocational education, primarily aims to equip students with essential theoretical knowledge and specific skills, enabling them to better tackle challenges and adapt to professional roles. However, the historical disconnection between theory and practice has been a persistent issue. In the early to mid-20th century, education placed greater emphasis on the imparting of theoretical knowledge, with practical activities often confined to designated weeks of professional internships, operating relatively independently from theoretical instruction. This often led to a detachment between theoretical understanding and practical application for students.

By the mid-20th century, the significance of practical teaching began to gain recognition, especially in applied and vocational education. The demand for practical teaching increased, resulting in longer durations for practical courses. Despite these changes, theoretical lectures continued to dominate, and practical courses remained relatively independent of theoretical ones, limited by curriculum scheduling and teaching facilities. Toward the end of the 20th century, project-based learning driven by real-world issues gained prominence. The focus shifted towards nurturing students' comprehensive competencies, emphasizing problem-solving skills. Students gradually began to integrate theory and practice while addressing real-world challenges.

In recent years, as professional fields have become more complex, societal expectations for students' practical capabilities have risen. Schools have intensified collaborations with businesses, establishing training bases to expose students directly to actual work scenarios. Simultaneously, Theoretical and Practical Teaching Strategies (TPTS) have emerged. These strategies seamlessly combine theory and practice within the conventional theoretical teaching process, utilizing real-world projects as catalysts to enhance students' practical abilities.

Many countries worldwide have been reinforcing efforts to cultivate students' practical skills. Western nations, in particular, place a strong emphasis on practical education (Silova et al., 2020). Numerous universities offer courses with a significant practical component, encouraging student participation in research and application projects. In Nordic countries, students not only acquire theoretical knowledge in classrooms but also actively engage in real projects, elevating their practical abilities (Einarsdottir et al., 2023). In China, the development and application of TPTS are gradually becoming a key focus of educational reform (Bao et al., 2024). Particularly in vocational education, fostering practical skills has become a national

priority. Important documents such as the Law of the People's Republic of China on Vocational Education and the National Vocational Education Reform Implementation Plan explicitly mention concepts and goals related to the TPTS. The TPTS stimulate students' interest and motivation for learning (Huang et al., 2023). They facilitate a deeper understanding of abstract concepts, nurture students' practical application abilities, and enhance their problem-solving skills. Ultimately, this approach contributes to the development of high-quality technical and skilled professionals, meeting the growing demands of society.

In response to the global and national imperatives, evaluating the implementation and effectiveness of the TPTS has become essential, particularly in high-skill, technology-driven disciplines such as automotive electronics. Understanding how these strategies affect both teaching quality and learning outcomes can inform not only local teaching practices but also broader vocational education reforms. For instructors, this study offers insights into how integrated methods enhance student engagement, support knowledge transfer, and strengthen the alignment between curricular content and industry demands. It also supports educators in refining their pedagogical approaches to better combine theoretical foundations with hands-on instruction. For institutions, particularly vocational colleges, this study underscores the importance of strategic investments in instructional resources, faculty development, and school–enterprise collaborations. The findings have practical implications for optimizing training bases, aligning course design with real-world challenges, and improving graduate employability. By evaluating a course as technically intensive as Vehicle Digital Control, the study offers concrete evidence on how integrated strategies can serve as a model for improving both teaching effectiveness and institutional competitiveness.

This study aims to assess the practical effectiveness of the TPTS as implemented in the Vehicle Digital Control course. It seeks to understand how such integration impacts students' interest in learning, knowledge acquisition, and real-world problem-solving abilities. The research also aims to identify the barriers that hinder effective implementation and to propose actionable recommendations to optimize teaching strategies for vocational education. The specific objectives are: (1) to determine the classroom participation effectiveness of the TPTS; (2) to analyze the difficulties encountered in the implementation of the TPTS; and (3) to identify better ways to promote and enhance the application of the TPTS.

## 2. Literature Review

### *2.1. Origins and Evolution of TPTS*

The TPTS is an educational approach that closely combines theoretical knowledge learning with practical operation skills training. It emphasizes the integration of theory and practice, aiming to enhance students' hands-on abilities and professional skills, while also stimulating their interest in learning. The educational philosophy of integrating teaching with practical instruction can be traced back to the pragmatism teaching theory system advocated by the renowned educator John Dewey. Dewey emphasized the principle of "learning by doing," which broke the shackles of the separation between theory and practice in traditional teaching (Hildebrand, 2022). With the evolution of the times, the TPTS has gradually gained recognition and development. Entering the 1990s, it was widely recognized and promoted in the field of vocational education, becoming an effective way to cultivate applied talents.

### *2.2. Research and Practices on TPTS*

Many authors have conducted extensive and in-depth research on TPTS. They believed that theory and practice were inseparable, and that the TPTS helped to improve students' interest in learning (Margevica-Grinberga & Laganovska, 2023; Null, 2023), thereby catalyzing positive outcomes (Daly-Smith et al., 2018; Glass & Kang, 2019; Ma'mun, 2018), effectively improving students' classroom behavior and performance. This connection highlighted the profound impact of the combination of theory and practice on all aspects of the educational experience. Against this backdrop, how to effectively implement the TPTS was obviously more critical. Gess-Newsome et al. (2019) and Grossman (2021) believed that the core ability of teachers was a key factor, and comprehensive training for teachers was needed (Hughes et al., 2023) to cleverly combine theoretical concepts with practical world applications, thus creating a comprehensive and influential learning environment. Janssens et al. (2023) then proposed that the learning place was more important, and they proposed a workplace-oriented teaching model to bridge the gap between theory and practice. For specific courses, most research focuses on medical, nursing and other related courses, such as Şimşek et al. (2023) found that in surgical nursing courses, system insufficiency, limited resources, and difficulties in the clinical learning environment were all challenges encountered in implementing theory and practice teaching strategies.

Domestic research on the TPTS started relatively late, beginning with the introduction and absorption of advanced foreign educational concepts, but has developed rapidly in recent years. The main research focused on the following aspects: First, the application of the TPTS in different professional fields. Many scholars had conducted sufficient research on how to effectively implement the TPTS in different professional fields such as intelligent welding (Jin & Du, 2024), automotive manufacturing (Deng et al., 2024), big data and auditing (Zhao, 2024), and had explored the implementation path of the TPTS. Second, curriculum construction and teaching reform under the TPTS. Some researchers believed that real work tasks (Ming, 2022; Sang et al., 2022) or real business cases (Chen et al., 2022) could be introduced into the curriculum, thereby establishing a tangible connection between theoretical concepts and their practical application, enriching the learning experience. In addition, in terms of teaching design, many researchers also had different views. For example, Zhang et al. (2019) believed that theory and practice teaching strategies should follow a fixed pattern, but some had also proposed their own teaching models, such as the six-step teaching method (Chen, 2019). This diversity of views highlighted the ongoing exploration and experimentation to find the most effective and suitable methods for the TPTS. Third, the development and utilization of teaching resources under the TPTS. Some scholars believed that designing and developing a practical and theoretical integrated teaching platform for automotive electronic control systems (Guo et al., 2022), using e-learning (Liang & Wei, 2022; Logo, 2023; Ren et al., 2022; Zheng et al., 2022) could create a cohesive learning environment, allowing theoretical principles to be directly applied to practical scenarios, improving students' ability to transfer knowledge to the real world, and effectively promoting the integration of theory and practice. Fourth, the requirements for teacher quality and ability under the TPTS. For example, Duan and Liu (2018) believed that enterprise teachers could be integrated into the dual-teacher classroom, providing students with insights from academic and industry perspectives, and cultivating a more comprehensive understanding of the subject.

The literature comprehensively combs the meaning of the TPTS and the current status of related research. It can be seen that researchers have recognized the importance of the TPTS and have carried out a lot of exploration and practice. These studies not only provide rich theoretical basis and practical experience, but also point out the direction for future research and practice. However, it is worth noting that although a large number of studies have discussed the effectiveness, key elements, and teaching strategies of the TPTS, research on

specific subject areas and course characteristics is still insufficient. In addition, most international cases in existing literature focus on healthcare disciplines, while neglecting the engineering field. Domestic research mainly conducts subjective analysis and evaluation from the perspective of teachers, and few researchers provide objective data analysis to support the study of TPTS. As a core professional course that students in vocational colleges must learn and master, the vehicle digital control course has the characteristics of being interdisciplinary and highly practical. Therefore, it is necessary to conduct research on the effectiveness of TPTS for students in vocational colleges participating in the vehicle digital control course.

### ***2.3. Theoretical Framework***

The TPTS is based on a series of educational theories and methods, aiming to promote the integration of theoretical knowledge and practical application, improve students' comprehensive literacy and problem-solving ability. The main theories adopted include constructivist theory and behaviorist theory.

*Constructivist theory:* Constructivist theory holds that learning is an active and individualized process, emphasizing that students construct their own knowledge system through interaction with the environment (Jonassen, 1999). In the TPTS, by introducing real work projects and setting work tasks, students can participate in practical projects and solve practical problems, combine theoretical knowledge with practical experience, and have a deeper understanding and application of the learned content.

*Behavioral theory:* Behavioral theory emphasizes shaping behavior through feedback and rewards and punishments (Watson, 1913). In the TPTS, students' practical operations in actual projects can be regarded as a behavior. When students complete practical operations, teachers provide real-time results and feedback, which can strengthen learning and stimulate students' interest and motivation in learning.

These theories provide a theoretical foundation for the TPTS, and emphasize the importance of student participation in practical operations and problem-solving. By integrating these theories, educators can better design and implement TPTS, in order to promote students' learning and development more comprehensively and effectively.

### **3. Methodology**

#### ***3.1. Research Design***

This study used qualitative descriptive design because it could deeply explore the subjective experiences and feelings of students. Through in-depth interviews and text analysis, it revealed the deep level experiences of students in the teaching process. Unlike quantitative analysis, qualitative research could capture students' emotions, attitudes, and coping strategies when facing challenges in practical operations. This deep understanding helped to obtain information beyond what quantitative data could provide, providing educators with more comprehensive and specific improvement directions, and optimizing the TPTS more targeted. By gaining a deeper understanding of individual differences and feedback from students, qualitative analysis would provide educators with more flexible and detailed guidance, promoting the continuous optimization of the TPTS.

#### ***3.2. Participants of the Study***

This study was conducted at a full-time ordinary higher vocational college located in the northwest region of China. The institute comprises 16 teaching departments, including the School of Automotive Engineering and the School of Mechanical Engineering. Purposive sampling was employed to select participants for the interviews. Teachers and students selected for participation were required to meet the following criteria: Teachers must have more than three years of teaching experience, have taught the Vehicle Digital Control course, and have implemented the TPTS in their teaching process; and Students must be enrolled in a class where the Vehicle Digital Control course was offered, and the instructor must have used the TPTS in actual teaching.

Based on the inclusion criteria, only three teachers were found to be eligible, and thus only these three were interviewed. Among the 39 students enrolled in the Vehicle Digital Control course taught by the three TPTS-implementing teachers, 10 were interviewed. Data saturation was reached at this point.

#### ***3.3. Instrumentation and Data Gathering Process***

This study collected data through interviews, and obtained data through in-depth one-on-one discussions with participants on current topics. There were seven questions in the interview. Questions 1 and 2 of the teacher questionnaire mainly determined the classroom

participation effectiveness of the strategies by asking teachers about the enthusiasm of students in the classroom; questions 3 and 4 analyzed the difficulties encountered in the implementation of the TPTS, asking teachers about their views on the practical training conditions and the difficulties encountered in the implementation of the TPTS; questions 5, 6, and 7 asked teachers what measures should be taken in the implementation of the TPTS to better promote the TPTS and improve students' professional ability. Questions 1 and 2 of the student questionnaire mainly determined the classroom participation effectiveness of the strategies by asking students about activities that could stimulate enthusiasm and promote the understanding of theoretical knowledge in the classroom; questions 3, 4, and 5 analyzed the difficulties encountered in the implementation of the TPTS, asking students about their views on the practical training conditions and the difficulties encountered in the participation of the TPTS; questions 6 and 7 asked students what measures should be taken in the implementation of the TPTS to better promote the TPTS.

The data collection process was carried out systematically to ensure the credibility and reliability of the study findings. Prior to conducting interviews, the researcher distributed consent forms to all selected participants. These forms outlined the purpose of the study, the voluntary nature of participation, potential risks, confidentiality measures, and the right to withdraw at any time without consequences. Participants were given sufficient time to review the consent forms, ask questions, and provide their signed agreement before proceeding with the interviews.

When consent was obtained, data collection commenced through in-depth, semi-structured interviews with three teachers and ten students. The interviews were conducted in a private and comfortable setting to encourage open and honest responses. A set of guiding questions were used to ensure consistency while allowing flexibility for participants to share their experiences in detail. The interviews focused on exploring the effectiveness of TPTS, challenges encountered, and potential areas for improvement.

To maintain accuracy and data integrity, interviews were audio-recorded with participants' permission. Additionally, the researcher took detailed field notes to capture non-verbal cues and contextual insights that could enhance the analysis. After the interviews, the recordings were transcribed verbatim to ensure a thorough and accurate qualitative analysis. Participants' identities were anonymized in the transcripts to protect their privacy and confidentiality.

Following data collection, the researcher conducted a thematic analysis to identify common patterns, insights, and themes emerging from the interviews. These findings were used to provide a deeper understanding of the impact of TPTS, ensuring that the research contributes valuable recommendations for future teaching improvements. To strengthen the credibility and trustworthiness of the data, member checking was conducted by sharing preliminary findings with selected participants to confirm the accuracy of interpretations. Additionally, peer debriefing was employed, where experienced colleagues reviewed the analysis and provided feedback, ensuring that the themes identified were grounded in the data. Throughout the research process, strict ethical guidelines were followed to uphold the integrity and reliability of the study.

### ***3.4. Data Analysis***

For the collected unstructured text, thematic analysis was mainly used for data analysis. The analysis process included the following 6 steps:

1. Transcription. Translate the data from online interviews or recordings into written documents using the edited transcription method.
2. Reading and familiarization. Read all data items multiple times and note down the content of interest during the reading process.
3. Encoding. Encode the text by highlighting phrases or sentences within the text.
4. Generate a theme. By examining the created code, identifying patterns, and proposing themes.
5. Define and name the theme. Provide a concise and easily understandable name for each topic.
6. Write it down. Write an analysis of the data based on research questions, objectives, and methods.

### ***3.5. Research Ethics***

This study upheld strict ethical guidelines to ensure the safety, rights, and well-being of all participants. Participation in this research were entirely voluntary, with individuals having the right to withdraw at any stage without any consequences. Prior to the interviews, participants received detailed information about the research project, including its objectives,

potential risks, and the measures taken to protect their confidentiality and anonymity. Informed consent was obtained to ensure that participants fully understand their role in the study.

Confidentiality and privacy were strictly maintained throughout the research process. If participants preferred not to disclose their identities, their anonymity was guaranteed. Additionally, all collected data were securely stored and only used for academic purposes, ensuring that personal information remained confidential. The dissemination of research findings was conducted in a way that protected the privacy rights of participants. Furthermore, participants had the opportunity to be informed of the study results if they expressed interest.

To minimize any potential risks, sufficient safeguards were in place to prevent physical, emotional, or psychological harm to participants. There was no foreseeable long-term adverse impact on participants due to their involvement in this study. Additionally, participants were not required to spend or use their personal resources for the research.

The selection of participants was conducted using objective and non-discriminatory procedures to ensure fairness and inclusivity. By adhering to these ethical standards, this study aimed to maintain the highest level of integrity while safeguarding the rights and well-being of all involved.

## 4. Findings and Discussion

### 4.1. Effectiveness of the TPTS

Table 1 presents the themes and subthemes on the effectiveness of TPTS in enhancing student learning experiences. It highlights the major aspects of improved student participation, deeper understanding of theoretical concepts, and enhanced professional competence. with teachers and students.

**Table 1**

*Themes and subthemes on the effectiveness of TPTS*

Major Theme	Subtheme	Supporting Evidence (Indicators from Interviews)
Improved Student Participation	Hands-on learning	<i>Students 2 and 6: "prefer using instruments and practical exercises over theory"</i> <i>Teacher 1: "physical demonstrations and hands-on troubleshooting"</i>
	Interactive activities	<i>Teacher 3: "group competitions and cooperative tasks"</i>

Major Theme	Subtheme	Supporting Evidence (Indicators from Interviews)
Deeper Understanding of Theory	Teamwork and collaboration	<i>Teacher 3: "group work promoting peer learning and cooperation"</i>
	Enhanced memory through practice	<i>Students 4 and 10: "better retention via practice"</i>
	Application of theory to practice	<i>Students 4 and 10: "bridging principles with real scenarios"</i>
	Integration of abstract concepts	<i>Teacher 1: "students face complex wiring despite understanding theory"</i>
	Improved professional competence	<i>Teacher 1 and 2: "real-life cases and industry collaboration to improve skills"</i>

***Improved Student Participation.*** The TPTS significantly improved student participation in class, and hands-on practical activities significantly stimulated students' enthusiasm. Teacher 1 mentioned that the "troubleshooting competition and quiz activities" created an interactive learning environment where students could directly participate in practical operations. This learning environment not only increased students' interest in learning, but also cultivated students' awareness of teamwork and problem-solving skills. Students also said that they preferred practical courses over theoretical courses. Students 2 and 6 mentioned that "using instruments to measure" was the main motivation for their active participation in class, and this activity made them feel that learning was more practical. Teacher 2 also pointed out that "students in vocational colleges obviously do not like theoretical courses, but prefer practical courses." The high level of student participation in practical courses shows that hands-on learning can resonate with students because of its interactivity and fun, and at the same time enable students to transform the theoretical knowledge they have learned into practical applications, thereby enhancing students' learning confidence and sense of achievement, and helping students better understand their career direction.

The findings are consistent with the view emphasized in behavioral theory that behavior is shaped through feedback and rewards and punishments (Watson, 1913). The positive feedback given by teachers to students during the process of completing operations effectively stimulates their interest in learning and increases their participation. In addition, this finding is also supported by research by Iyamuremye et al. (2023), which found through a

blended study design that students are more inclined to engage in hands-on activities. The organic combination of theoretical teaching and practical teaching can enhance students' learning enthusiasm and interest (Zhang et al., 2024), thereby increasing their participation in the classroom (Margevica-Grinberga & Laganovska, 2023; Null, 2023).

*Students better understand and apply theoretical knowledge.* The practical part of the course helps students understand theoretical knowledge and apply theoretical knowledge to practical problems. Teacher 1 emphasized that theoretical teaching focuses on principles, while practical teaching focuses on practical operation. The two teaching methods complement each other. Through practical operation, students can better transform abstract theoretical knowledge such as structure and principle into specific skills, thereby deepening their understanding of knowledge. Students 4 and 9 said that "hands-on operation" is an effective way to understand theoretical knowledge, and this personal experience can make them remember the knowledge more deeply. Student 10 further explained, "By operating the automotive electronic control equipment by hand, I can better understand the circuit principles and control logic learned in the theoretical class." These feedbacks show that practical exercises not only improve students' participation, but also deepen their understanding of theoretical knowledge. This improves students' mastery of theoretical knowledge, helps them better apply theoretical knowledge to practical problems, and enhances their professional competitiveness.

It reflects constructivist theory, emphasizing that students construct their own knowledge system through interaction with the environment (Jonassen, 1999). By solving practical projects and problems, students can better understand the theoretical knowledge they have learned and apply it in practice. Research also have shown that student engagement in hands-on learning strengthens students' understanding of the theoretical knowledge they have learned (Van Ryneveld et al., 2020; Daly-Smith et al., 2018) and helps them apply it to real-world situations (Prianto et al., 2022; Glass & Kang, 2019; Ma'mun, 2018). These findings emphasize the importance of hands-on teaching.

#### ***4.2. Difficulties in the Implementation of the TPTS***

Table 2 presents the major themes and subthemes illustrating the specific difficulties encountered in the TPTS implementation.

**Table 2***Themes and subthemes on difficulties in the implementation of TPTS*

<b>Major Theme</b>	<b>Subtheme</b>	<b>Supporting Evidence (Indicators from Interviews)</b>
Insufficient Equipment and Resources	Limited equipment and materials	<i>Teacher 1: "insufficient equipment, expensive consumables, and limited venues"</i> <i>Students 5 and 7: "damaged multimeters" and "unresponsive sensors,"</i>
	Resource constraints affect learning equity	<i>Both teachers and students observed that limited resources reduced participation and restricted learning depth.</i>
Difficulty Combining Theory with Practice	Application gap between theory and practice	<i>Teacher 1: "students understand circuit principles in theory but struggle with complex wiring during hands-on tasks."</i> <i>Student 7: "hard to apply Wheatstone bridge theory to engine measurements"</i>
	Weak theoretical understanding hinders analysis	<i>Teacher 2: students "could not understand motor inspection signals," especially when using oscilloscopes and waveforms.</i> <i>Students 3 and 9: "weak grasp of theoretical knowledge,"</i>
	Need for more effective teaching strategies	<i>Teachers proposed methods such as project-based teaching, case-based learning, and simulation software to bridge the gap.</i>
Insufficient Practical Skills of Teachers	Limited teacher skills and experience	<i>Teacher 1: "weak practical operation skills of teachers" and "difficulty in coordinating teaching schedules."</i>
	Professional development needed	<i>Teachers emphasized the need for more practice opportunities, high-quality textbooks, and cooperation with industry for updated cases.</i>
	Skills deficit impacts learning outcomes	<i>Teacher 1: "limited teacher skills can lead to an inability to fully guide students in practical sessions, reducing learning effectiveness"</i>

***Insufficient equipment and resources.*** Both teachers and students emphasized that the lack of equipment and resources is the main obstacle to the implementation of the TPTS. Teacher 1 mentioned that "insufficient equipment, expensive consumables, and limited venues" are the main problems in practical teaching, which not only reduces students' learning

efficiency, but also limits the depth and breadth of teaching content, resulting in teachers being unable to carry out more and more complex practical projects, affecting students' understanding of cutting-edge technologies. Teacher 3 also pointed out that "insufficient practical equipment means that not all students can participate in practical operations at the same time", which leads to reduced participation of some students and affects students' learning experience. In addition, students also mentioned equipment availability and quality issues. Students 5 and 7 said that the "multimeters" used for detection were mostly damaged and "the sensor response was not sensitive enough". Student 9 also pointed out that "insufficient and old equipment" affected their learning experience. These problems highlight the need to increase investment in teaching resources to ensure that all students can participate in practical learning equally, thereby further improving teaching effectiveness.

This difficulty resonates with the research of Delaney et al. (2024) and Iyamuremye et al. (2023), who highlight that teachers face similar challenges when implementing practical activities, namely a lack of resources and equipment. This difficulty makes it difficult to ensure that every student receives sufficient training in practical operations (Şimşek et al., 2023), thereby affecting the implementation effectiveness of the TPTS.

*Students have difficulty combining theory with practice.* Another common challenge is the difficulty students have in applying theoretical knowledge to practical tasks. On the one hand, students master theoretical knowledge, but find it difficult to apply theory to practical problems when applying it in practice. For example, Teacher 1 noted that students "understood the circuit principles in theory, but were confused when faced with complex wiring and unfamiliar components". Student 7 found it "difficult to apply the theoretical knowledge of the Wheatstone bridge to actual engine measurements". On the other hand, students were able to perform practical operations, but due to their weak grasp of theoretical knowledge, they had difficulty in further analyzing the test results. For example, both Teachers 2 and 3 observed that students "did not understand the detected signals" because they did not have a deep enough grasp of theoretical knowledge. Students 3 and 9 also noted "did not understand the sensors" and "some theoretical knowledge was not clear". These difficulties show that students need to be able to apply theoretical knowledge while being able to apply it in practice. This places requirements on teachers' teaching design capabilities, and teachers should be able to use appropriate teaching methods to improve students' ability to apply theory to practice.

This is consistent with the findings of Li (2024), who pointed out that vocational college students have weak learning ability and low levels of learning transformation. The presence and guidance of teachers play a crucial role in their effective theoretical learning and the translation of theoretical knowledge into practical operation (Jossberger et al., 2018). Teachers need to update their teaching philosophy and adopt more flexible and interesting teaching methods based on students' learning situations to help them learn and understand theoretical knowledge, and effectively transform it into practical operations (Deng et al., 2024; Chen, 2019).

***Insufficient practical skills of teachers.*** The lack of practical skills of teachers themselves is also one of the obstacles to the effective implementation of the TPTS, which not only affects the organization of the practical teaching part, but also affects the updating of teaching content. Teacher 1 mentioned that “weak practical operation of teachers” and “difficulty in coordinating teaching arrangements” were the main difficulties encountered. This deficiency may result in teachers being unable to fully guide students in practical teaching, thus affecting students' learning outcomes. Teacher 2 emphasized the importance of practical experience, saying that he would often participate in real car repairs and had accumulated valuable teaching cases in forensic identification. This comparison shows that although some teachers have accumulated strong practical skills through experience, other teachers may need more training and support to provide effective practical teaching, a concern that has been widely documented in related studies. Multiple investigators (Yeap et al., 2021; Wu & Liao, 2025) emphasize that skilled teachers are essential for an effective teaching process in TVET, and that teachers' lack of skills and experience can affect the skills instruction to students (Duan & Liu, 2018).

#### ***4.3. Suggestions for promoting the TPTS***

***Increase resource investment.*** Both teachers and students emphasized the need to increase investment in teaching resources. Teacher 1, Teacher 3, Student 2, and Student 6 all pointed out that only by providing "sufficient practical training equipment" can the TPTS be better carried out. Only by ensuring sufficient practical training equipment can each student have enough time for practical operation, students can master practical skills, and thus better integrate theory with practice, and teachers can better arrange course content. In addition,

Teacher 1 and Teacher 2 said that only real and cutting-edge "teaching cases" can make practical projects closer to the real needs of enterprises, help students better understand the challenges in actual work, and improve students' professional abilities. In addition, Teacher 1, Teacher 3, Student 5, Student 7, Student 8, and Student 10 also mentioned course resources such as "videos and online courses", which can help students learn theoretical and practical knowledge clearly and repeatedly.

These suggestions highlight the importance of providing sufficient resources to support teaching and learning. Research has also shown that adequate resources can be effective in supporting teaching and learning. Ma (2021) emphasized that schools should improve the facilities of the training base in a variety of ways, and update the commonly used technology and equipment in a timely manner to meet the needs of students for full learning, so as to improve students' participation in the classroom. Mo et al. (2025) emphasized that schools can take the initiative to connect with enterprises, make full use of resources inside and outside the school, carry out more forms of school-enterprise cooperation projects, provide students with more practical opportunities, and improve their practical skills. In addition, electronic learning resources and integrated teaching platforms can also be introduced, allowing students to view and learn resources anytime and anywhere. At the same time, feedback on students' learning outcomes can be provided to monitor each student's learning situation and provide targeted guidance to improve teaching effectiveness (Liang & Wei, 2022; Logo, 2023; Zheng et al., 2022).

***Strengthen teacher training.*** Improving teachers' practical skills can enable teachers to better implement the TPTS. Teacher 1 advocates "improving teachers' practical skills through professional training" to help teachers master the latest practical techniques and teaching methods, design teaching content from actual work projects, and use the latest teaching methods to enhance students' learning interest, which is conducive to improving students' classroom participation and further improving students' professional ability. Teacher 2 emphasized the value of practical experience in enriching teaching practice, "I often participate in car repairs in practice and have accumulated a lot of car repair cases. In addition, during the process of forensic appraisal, I have conducted in-depth research on car steering and braking, etc., which is very helpful for my related teaching." These insights show that targeted training programs and providing teachers with practical opportunities can help teachers

integrate actual work experience into teaching, thereby significantly improving the quality of the practical teaching part of the TPTS (Hughes et al., 2023). This is consistent with the research of Khan and Abdullah (2019), who highlight the need to provide appropriate training opportunities for teachers in order to respond to the changing industry, so that teachers can become more familiar with various skills and information, thereby improving the effectiveness of classroom teaching.

***Adopt innovative teaching methods.*** Both teachers and students proposed the need to improve teaching methods to better combine theory and practice. Project-based learning and case teaching were frequently mentioned. Teacher 1, Student 8, Student 9, and Student 10 all mentioned "project-based teaching", which combines theoretical knowledge with practical operations based on real work projects, thereby deepening the understanding of knowledge and completing the integration of knowledge and skills. In addition, Teacher 1 and Teacher 2 both mentioned "case teaching", which stimulates students' interest in learning by analyzing real fault cases, which is conducive to the learning of theoretical knowledge. Teacher 3 emphasized the advantages of "group teaching method", believing that this method can promote cooperation and knowledge sharing among students. These innovative methods are expected to create a more dynamic and attractive learning environment and promote the in-depth understanding and application of knowledge. In addition, teachers emphasized the importance of regularly collecting and integrating student feedback to adjust teaching strategies. Teacher 1, Teacher 2, and Teacher 3 all mentioned the need to analyze common problems based on student feedback to clarify teaching difficulties and adjust the teaching progress to optimize learning outcomes. This shows that the use of student-centered and innovative teaching methods can enhance the effectiveness of teaching strategies that combine theory with practice.

The effectiveness of innovative teaching methods is consistent with the results of broader research. For example, the authenticity of projects in project-based learning enables students to relate themselves to the learning content, thereby increasing their interest and importance in the project (Renninger & Hidi, 2022; Ming, 2022; Sang et al., 2022), and the social aspects of case-based learning and the application of knowledge to real-world cases have been identified as potential motivators to increase students' interest and their perception of the importance of the subject (Loyens et al., 2022; Chen et al., 2022).

Table 3 highlights three major areas of difficulty: insufficient equipment and resources, students' difficulty combining theory with practice, and insufficient practical skills of teachers. Corresponding to these challenges are three strategic suggestions: increasing resource investment, adopting innovative teaching methods, and strengthening teacher training.

**Table 3**

*Difficulties encountered during the implementation of TPTS and improvement suggestions*

<b>Difficulties</b>	<b>Suggested Improvements</b>
Insufficient equipment and resources	Increase resource investment
Students have difficulty combining theory with practice	Adopt innovative teaching methods
Insufficient practical skills of teachers	Strengthen teacher training

The first challenge, insufficient equipment and resources, highlights a key barrier in ensuring the effectiveness of practical teaching. Both teachers and students reported a lack of adequate tools and up-to-date materials, which hinder students' ability to engage fully in hands-on activities and limit teachers' capacity to conduct complex projects. This resonates with the need to increase resource investment. By ensuring access to sufficient and high-quality practical equipment, incorporating real-world teaching cases, and expanding digital learning materials, educational institutions can create an environment where every student can develop practical skills effectively and where theory and practice can be seamlessly integrated.

The second challenge focuses on students' difficulty in applying theoretical knowledge to practical situations. This gap can be addressed by adopting innovative teaching methods such as project-based learning, case teaching, and group work. These methods can promote the integration of theoretical and practical knowledge, making learning more interactive, engaging, and reflective of real-world demands. Moreover, the importance of regularly analyzing student feedback to refine teaching strategies underscores the value of student-centered approaches in improving teaching effectiveness.

The third challenge, insufficient practical skills of teachers, reflects the need for targeted professional development. Teacher training and exposure to industry practices are crucial in enhancing the quality of practical teaching. By equipping teachers with up-to-date

skills and experiences, they can design relevant and engaging content, guide students more effectively, and address evolving industry needs.

Table 4 presents the proposed TPTS Framework which integrates theory and practice in technical courses like vehicle digital control, electronics, or mechatronics. It is based on constructivist theory, in which students construct knowledge actively by collaborating on real-world projects and group work, and behaviorist theory, in which learning behavior is formed through feedback and reinforcement.

**Table 4**

*TPTS framework for technical courses*

<b>Component</b>	<b>Description</b>
Key Inputs	Resource investment (equipment, digital tools), teacher development and training, innovative instructional design
Core Strategies	Integrated Theoretical & Practical Strategies combining constructivist and behaviorist approaches; project-based and case-based learning, simulations
Active Learning	Hands-on activities, competitions, group work, and problem-solving tasks to increase engagement and participation
Theory-Practice Bridge	Real-world projects, scaffolded knowledge construction, and immediate feedback to deepen understanding and apply concepts
Feedback Mechanisms	Real-time feedback, rewards and reinforcement, student reflections to strengthen learning outcomes
Expected Outcomes	Higher student participation, deeper theoretical understanding, improved practical competence, better alignment with industry requirements

Key inputs do not just refer to material resources, but also human resources, teachers with the current skills and techniques. Core strategies entail a holistic integration of theoretical content and practice through techniques such as project-based learning and case studies to enable students to gain understanding as well as applicable skills. Finally, this model is intended to increase student engagement, enrich theoretical insight, enhance practical skill, and harmonize technical education with the requirements of industry, offering a reproducible model for other technical courses.

## 5. Conclusion

The findings show that TPTS effectively promotes student participation and greater understanding of theoretical knowledge through practice. Yet, problems remain, such as limited availability of fully functional equipment, continued deficiency in theoretical understanding translated into practice, and lack of teacher practical skills. These constraints hold back the full potential of TPTS, close off opportunities for students to use theory in challenging activities, and restrict teachers' potential to create and provide good-quality, integrated instruction.

The findings underpin the imperative need for schools and colleges to raise the level of investment in high-quality resources and state-of-the-art training facilities to facilitate practical learning. Teachers also need to be engaged in ongoing professional growth in order to advance their theoretical as well as practical skills so that they can provide stimulating, real-world learning experiences. Additionally, infusing new teaching methods such as project-based learning, case studies, and group work is important for developing interactive learning contexts that facilitate enhanced knowledge transfer and problem-solving capabilities.

There must be ongoing feedback channels from the teachers and students to guarantee teaching approaches are flexible enough to keep responding to changing learners' needs and industry requirements. By tackling these essential determinants, institutions can successfully close the practice-theory gap and enhance graduates' preparedness for technical professions.

This research expands the use of constructivist and behaviorist theories to vocational STEM education and puts forward a holistic TPTS model that combines resource investment, educator development, and innovative pedagogical design. The model provides a scalable and flexible framework for enriching technical education that can accommodate both teacher effectiveness and student learning outcomes. It offers a useful guideline for instructors and institutions in implementing and iterating on TPTS for various technical courses.

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**Institutional Review Board Statement**

This study was conducted in accordance with the ethical guidelines set by the Research Ethics Committee of the University of Baguio.

**AI Declaration**

The authors utilized ChatGPT and QuillBot in the preparation of this work to improve readability and language. The authors reviewed and edited all content produced through the use of these tools, for which they fully accept responsibility in the final publication. Consensus AI and Elicit AI were used for purposes of literature review, while Scribbr was used for reference formatting.

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