Teacher Competence in Electrical Installation and Maintenance: An Assessment Using Shulman's Pedagogical Content Knowledge Model

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ABSTRACT

Teacher competence is essential in technical-vocational education and training (TVET), particularly in practice-oriented fields like Electrical Installation and Maintenance (EIM). Shulman's Pedagogical Content Knowledge (PCK) Model, which integrates Content Knowledge (CK), Pedagogical Knowledge (PK), and Pedagogical Content Knowledge (PCK), provides a framework for evaluating teacher competence.A **quantitative descriptive design** was employed, involving **40 purposively selected teachers** from TVET schools in Surigao del Sur, Philippines. Data were collected through a validated Likert-scale questionnaire and analyzed using weighted means.Teachers rated themselves positively across all domains. **PCK (4.10, Agree)** emerged as the strongest, followed by **PK (4.06, Agree)** and **CK (3.86, Agree)**. Strengths included designing hands-on activities, fostering critical thinking, and integrating technology, while lower scores were reported in assessment literacy and technical demonstrations.TVET teachers demonstrate strong competence in integrating pedagogy with content but face challenges in assessment and demonstration skills. Professional development in authentic assessment, practice-based training, and industry immersion is recommended. Future studies should evaluate the long-term effects of these interventions on teaching quality and learner outcomes.

Keywords—Teacher Competence, Pedagogical Content Knowledge, Content Knowledge, Pedagogical Knowledge, Shulman's Model, Technical-Vocational Education, Electrical Installation And Maintenance

INTRODUCTION

Teacher competence is central to the quality of technical-vocational education and training (TVET), where instruction must balance theoretical knowledge with practical application. In fields such as Electrical Installation and Maintenance (EIM), effective teaching requires subject mastery and the ability to integrate pedagogy and practice to prepare learners for workforce readiness (Mohd Noor et al., 2024; Kiryakova, 2024).

This study adopts Shulman's Pedagogical Content Knowledge (PCK) Model, which emphasizes the integration of Content Knowledge (CK), Pedagogical Knowledge (PK), and Pedagogical Content Knowledge (PCK) as essential dimensions of teacher competence (Lavonen, 2023; Zhou et al., 2023). Anchored in the Philippine Professional Standards for Teachers (DepEd Order No. 42, s. 2017) and TESDA's Training Regulations for EIM NC II, the study also aligns with Sustainable Development Goal 4, which calls for strengthening teacher quality to achieve inclusive and equitable education.

Despite these frameworks, challenges persist as many TVET teachers face limitations in assessment practices, practical demonstrations, and institutional support (Jafar et al., 2020; Sixabayi, 2023; Campos et al., 2025). While previous studies have highlighted the importance of teacher competence in TVET, much of the literature focuses on general teacher education or broader competency frameworks, leaving limited empirical evidence on how Shulman's PCK specifically applies to technical-vocational contexts such as Electrical Installation and Maintenance (EIM). This gap underscores the need to examine how teachers perceive their competence across CK, PK, and PCK within practice-oriented disciplines. By addressing this underexplored area, the study aims to identify both strengths and weaknesses in teacher competence, thereby generating evidence-based recommendations for professional development and enhanced instructional practice in technical-vocational education.

Conceptual Framework

This study is primarily grounded in Shulman's Pedagogical Content Knowledge (PCK) Model, which explains teacher competence as the intersection of three domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Pedagogical Content Knowledge (PCK). According to Shulman, effective teaching requires not only mastery of subject matter (CK) and general pedagogical strategies (PK), but also the ability to merge these domains to make content comprehensible and meaningful for learners (PCK).

In the context of technical-vocational education and training (TVET), particularly in Electrical Installation and Maintenance (EIM), PCK is critical because it enables teachers to link theoretical concepts with hands-on, practice-based instruction. The framework emphasizes that student learning depends on teachers' subject expertise and their ability to design experiential activities, address misconceptions, and connect classroom instruction with real-world applications.

While Shulman's model forms the core of this study, the framework is further contextualized by national and global standards. The Philippine Professional Standards for Teachers (PPST) and TESDA Training Regulations for EIM NC II highlight the expectation that teachers must combine technical certification with effective pedagogy. At the same time, Sustainable Development Goal 4 (SDG 4) underscores the broader mandate of producing competent teachers to ensure equitable and quality education. These standards serve as external drivers that reinforce the relevance of PCK in preparing industry-ready graduates.

The conceptual framework positions PCK as the central measure of teacher competence, shaped by CK and PK and situated within institutional and global education priorities. This framework guided the study in assessing teachers' self-perceptions of competence across the three domains, aiming to identify strengths and areas requiring professional development.

Significance of the Study

This study is significant as it provides an evidence-based evaluation of teacher competence in the context of TVET, specifically within Electrical Installation and Maintenance. By applying Shulman's PCK framework, the research extends understanding of how teachers integrate content mastery with pedagogical strategies in practice-oriented disciplines. The findings contribute to institutional and policy-level discussions on teacher development, offering insights for designing professional development programs that strengthen theoretical and practical instructional skills. Furthermore, the study addresses national and global priorities, such as the PPST, TESDA training standards, and Sustainable Development Goal 4, by generating actionable knowledge that can improve instructional quality, enhance student learning outcomes, and align TVET programs more closely with labor market demands.

LITERATURE REVIEW

Teacher competence in technical-vocational education and training (TVET) is widely recognized as a multidimensional construct that integrates subject expertise, pedagogy, and the capacity to apply both in practice. Shulman's Pedagogical Content Knowledge (PCK) Model has long influenced this discourse, positioning PCK as the unique form of knowledge that enables teachers to transform subject matter into meaningful learning experiences. While Shulman provides the foundation, subsequent scholars such as Grossman (1990), Cochran et al. (1993), and Ball et al. (2008) expanded PCK to emphasize curriculum knowledge, the contextual nature of teaching, and the role of professional judgment in linking pedagogy with learners' needs. In TVET contexts, where instruction must combine theoretical mastery with hands-on skills, these expanded perspectives on PCK become particularly salient.

Several studies affirm that PCK underpins effective technical instruction by enabling teachers to connect disciplinary content with real-world practice. In Asia, research on Malaysian TVET institutions shows that knowledge, skills, and attitudes anchored in PCK are key predictors of teacher competence, strongly influencing instructional quality and learner outcomes (Omar et al., 2020). Similarly, studies highlight the need for competency frameworks to evolve in the Industry 4.0 era, ensuring that teachers remain technically

proficient while adapting their pedagogy to emerging demands (Jafar et al., 2020; Perera et al., 2024). By contrast, African scholarship underscores unevenness in pedagogical practices and institutional support. For instance, Sixabayi (2023) documents how lecturers' PCK-driven pedagogy varies significantly across South African colleges, while Gondwe and Waghid (2021) stress the need to embed sustainability competencies to ensure vocational training contributes to broader societal transformation. These regional differences highlight that while Asian contexts often foreground technological adaptation and industry alignment, African research emphasizes institutional disparities and sustainability as critical challenges.

The integration of technology has further expanded the PCK framework into the Technological Pedagogical Content Knowledge (TPACK) model, underscoring the importance of balancing pedagogy, content, and technology in contemporary TVET teaching. Studies from Malaysia and Vietnam reveal that while teachers recognize the value of technology-enhanced instruction, they continue to struggle with full adoption due to limited resources and training (Abdullah et al., 2022; Nguyen et al., 2022). Conversely, European analyses emphasize proactive digital transformation, showing how professional development in TPACK significantly enhances teachers' ability to support digitalized, practice-based learning (Schroeter et al., 2025). This contrast underscores how contextual factors—such as infrastructure and institutional support—mediate the extent to which teachers operationalize TPACK in vocational classrooms.

Beyond technology, sustainability and future-readiness have emerged as global priorities. Diao and Hu (2022) developed a TVET teacher competency scale that integrates PCK with sustainability competencies, while African perspectives argue that embedding sustainability into teacher frameworks is vital for aligning education with societal needs (Gondwe & Waghid, 2021). Meanwhile, in Asia, work-integrated learning models are increasingly promoted to strengthen the connection between school and industry, enhancing teachers' ability to deliver competence-based instruction (Mensah et al., 2022; Okolie et al., 2024). These comparisons show that while sustainability dominates the African discourse, Asian and European studies tend to prioritize industry and digital readiness.

Additional research reinforces the multidimensional nature of teacher competence, with findings converging on both strengths and gaps. In Asia, studies have identified assessment literacy as a recurring challenge, with teachers often relying on traditional methods rather than authentic, performance-based assessments (Chan et al., 2023). In Africa, similar gaps appear in the ability to adapt pedagogy to diverse learning environments, reflecting systemic inequities across institutions (Sixabayi, 2023). At the same time, global systematic reviews reaffirm that PCK remains central in aligning theory with practice while calling for frameworks that are more dynamic, context-responsive, and industry-aligned (Tan et al., 2023; Zhou et al., 2023).

Taken together, these studies suggest that while Shulman's PCK framework remains a cornerstone for understanding teacher competence, its expanded interpretations—integrating technology, sustainability, and contextual adaptation—are essential for meeting the evolving demands of TVET. The comparative evidence shows that Asia emphasizes technological integration and industry alignment, Africa highlights institutional disparities and sustainability, and Europe advances digital transformation through structured professional development. These contrasts reveal that teacher competence is not a static construct but one that must evolve in response to both global trends and local realities. Addressing persistent challenges in assessment, digital adoption, and sustainability through targeted professional development is thus critical for ensuring that TVET teachers remain effective and future-ready.

Synthesis

Teacher competence in technical-vocational education emerges as a dynamic construct shaped by global demands and contextual realities. In Asia, research highlights the importance of aligning pedagogy with rapid digital transformation and industry requirements, with growing emphasis on TPACK and work-integrated learning. By contrast, African studies point to uneven pedagogical practices and systemic institutional challenges, while also stressing the integration of sustainability competencies as a means of linking TVET to broader social development goals. European contexts, meanwhile, underscore structured professional development and digital transformation as central to strengthening teacher capacity. These regional contrasts reveal that while global trends converge on the multidimensionality of competence, the specific priorities differ:

Asia prioritizes industry alignment and technology, Africa emphasizes sustainability and equity, and Europe focuses on professional development and digital readiness. Collectively, the evidence underscores that advancing TVET teacher competence requires both shared frameworks and localized adaptations to ensure instructional quality and workforce relevance.

METHODOLOGY

Research Design

This study employed a quantitative descriptive design to assess teacher competence using Shulman's Pedagogical Content Knowledge (PCK) Model, focusing on the domains of Content Knowledge (CK), Pedagogical Knowledge (PK), and Pedagogical Content Knowledge (PCK).

Locale of the Study

The research was conducted in technical-vocational schools located in the municipalities of Carrascal, Cantilan, Madrid, Carmen, and Lanuza, Surigao del Sur, Philippines.

Respondents

The respondents were 40 purposively selected teachers handling Electrical Installation and Maintenance (EIM) and electricity-related exploratory subjects. While purposive sampling ensured that participants were directly engaged in technical-vocational instruction, the sample was limited to one province, which restricts the generalizability of findings to other regions or broader TVET contexts.

Research Instrument

Data were collected using a validated survey questionnaire aligned with Shulman's PCK framework. The instrument measured teacher competence across CK, PK, and PCK using a five-point Likert scale ranging from *Strongly Disagree (1.00–1.49)* to *Strongly Agree (4.50–5.00)*. As the study relied solely on self-reported data, it is acknowledged that responses may have been influenced by social desirability bias, potentially inflating competence ratings. Incorporating classroom observations or student evaluations in future studies would strengthen the validity of the findings.

Data Analysis

Responses were analyzed using descriptive statistics, specifically the weighted mean, to determine teachers' competence levels across the three domains.

Ethical Considerations

Ethical protocols were strictly followed. Participation was voluntary, informed consent was obtained, and confidentiality was maintained by ensuring anonymity and reporting only aggregated data.

Limitations

This study is limited in several respects. First, it relied solely on self-reported data, which may have introduced social desirability bias and inflated competence ratings. Future studies could triangulate findings with classroom observations, student evaluations, or peer assessments to strengthen validity. Second, the sample was restricted to 40 purposively selected teachers from one province in Surigao del Sur, which limits the generalizability of the results to broader TVET contexts. Expanding the sample across multiple regions and employing probability sampling would provide a more representative picture of teacher competence in technical-vocational education. Despite these limitations, the study offers valuable insights into teacher competence using Shulman's PCK framework and identifies areas for targeted professional development.

RESULTS

The weighted mean scores of teacher competence based on Shulman's Pedagogical Content Knowledge (PCK) Model are presented in Table 1. Findings are organized under three domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Pedagogical Content Knowledge (PCK).

Table 1. Weighted Mean of Teacher Competence Based on Shulman's PCK Model

Terms and Statements	**Weighted Mean**	**Verbal Interpretation**
A. Content Knowledge (CK)		
I have a strong understanding of electrical installation principles and applications.	3.9	Agree
I can effectively explain complex electrical concepts to my students.	3.75	Agree
I stay updated with advancements in electrical installation techniques and technologies.	4.0	Agree
I can troubleshoot and solve technical problems related to electrical installation.	4.0	Agree
I am confident in demonstrating electrical installation procedures to students.	3.65	Agree
Average Weighted Mean for CK	**3.86**	**Agree**
B. Pedagogical Knowledge (PK)		
I use various teaching strategies to accommodate different student learning styles.	4.05	Agree
I effectively manage classroom activities to create an engaging learning environment.	3.9	Agree
I assess student understanding through diverse assessment methods.	3.85	Agree
I encourage critical thinking and problem-solving among students.	4.25	Strongly Agree
I integrate technology to enhance my teaching methods.	4.25	Strongly Agree
Average Weighted Mean for PK	**4.06**	**Agree**
C. Pedagogical Content Knowledge (PCK)		
I relate electrical installation concepts to real-world applications to enhance student understanding.	4.0	Agree
I modify my teaching strategies based on student feedback and performance.	4.1	Agree
I design hands-on activities that align with electrical installation theory.	4.25	Strongly Agree
I am skilled in identifying common misconceptions students have about electrical installation.	4.0	Agree

I use instructional materials effectively to support my teaching.	4.15	Agree
Average Weighted Mean for PCK	**4.1**	**Agree**
Legend: 4.50-5.00 -Strongly Agree3.50-4.49 -Agree2.50-3.49 -Neutral1.50-2.49 -Disagree1.00-1.49 -Strongly Disagree		

Regarding Content Knowledge (CK), the average weighted mean was 3.86 (Agree), suggesting that teachers generally perceive themselves as competent in understanding and applying electrical installation principles. The highest scores were observed in staying updated with advancements (4.00, Agree) and troubleshooting and problem-solving (4.00, Agree). The lowest mean score was recorded in demonstrating installation procedures (3.65, Agree), indicating this as an area where teachers feel less confident.

For Pedagogical Knowledge (PK), the average weighted mean was 4.06 (Agree), which indicates a higher level of perceived competence than CK. Teachers strongly agreed that they encourage critical thinking (4.25) and integrate technology in their teaching (4.25). On the other hand, the lowest rating within this domain was in using diverse assessment methods (3.85, Agree), suggesting room for improvement in evaluation practices.

Pedagogical Content Knowledge (PCK) noted the highest domain score, with an average weighted mean of 4.10 (Agree). Teachers strongly agreed on designing hands-on activities aligned with theory (4.25) and reported highly effective use of instructional materials (4.15). Comparatively lower ratings were given to identifying student misconceptions (4.00) and relating lessons to real-world applications (4.00).

Overall, the results show that teachers rated themselves positively across all domains, with PCK emerging as the strongest area, followed by PK and CK. These findings suggest that while teachers feel confident in integrating pedagogy with content, challenges remain in assessment literacy and in demonstrating technical skills in practice.

DISCUSSION

The findings of this study demonstrate that teachers exhibit strong competence across Shulman's three domains of Content Knowledge (CK), Pedagogical Knowledge (PK), and Pedagogical Content Knowledge (PCK). Among these, PCK emerged as the strongest area, suggesting that teachers can blend subject matter expertise with effective pedagogy. This is particularly important in technical-vocational contexts, where learning depends on theoretical understanding and practical application of knowledge. The following sections discuss the results concerning existing literature, highlighting both areas of strength and aspects that require further development.

Content Knowledge (CK)

The findings indicate that teachers perceive themselves as competent in content knowledge, with an average weighted mean of 3.86 (Agree). High scores in staying updated with advancements (4.00) and problem-solving (4.00) highlight teachers' confidence in maintaining subject matter expertise. However, the lowest score was recorded in demonstrating installation procedures (3.65), suggesting challenges in translating theoretical knowledge into practical demonstrations. This limitation reflects broader issues in technical-vocational contexts, where the ability to perform and demonstrate technical tasks is as essential as understanding them. Research indicates that such gaps often arise from limited access to continuous technical training, outdated equipment in schools, and insufficient peer-learning mechanisms, all of which restrict teachers' opportunities to refine practical competencies (Campos et al., 2025). Strengthening professional development programs that emphasize practical pedagogy, ideally supported by industry partnerships, may address this weakness.

Pedagogical Knowledge (PK)

The average weighted mean for pedagogical knowledge was 4.06 (Agree), showing that teachers demonstrate strong pedagogical competence. Teachers scored highly in encouraging critical thinking (4.25) and integrating

technology in teaching (4.25), reflecting alignment with 21st-century teaching frameworks. These findings correspond with recent studies showing that applying the Technological Pedagogical Content Knowledge (TPCK) model enhances classroom engagement and strengthens teachers' ability to integrate ICT effectively (Urbano Gutiérrez et al., 2025). However, the relatively lower score in assessment practices (3.85) suggests the need to diversify approaches. One explanation may be systemic reliance on traditional, written assessments in TVET schools, coupled with a lack of training in authentic and performance-based assessment methods. Institutional constraints such as large class sizes, limited time for individualized assessment, and insufficient support for developing alternative assessment tools may also discourage innovation in evaluation. Prior studies in teacher education emphasize that authentic assessments are particularly suited for practice-oriented fields, providing more accurate insights into student learning (Zulkarnain et al., 2025).

Pedagogical Content Knowledge (PCK)

PCK emerged as the strongest domain, with an average weighted mean of 4.10 (Agree). Teachers scored highest in designing hands-on activities (4.25) and effective use of instructional materials (4.15). This suggests a strong capacity to integrate subject matter expertise with pedagogy, a hallmark of Shulman's PCK framework. Hands-on, experiential learning is particularly critical in technical-vocational education, where knowledge transfer depends heavily on practice-based tasks. Studies in TVET confirm that project-based and experiential approaches strengthen problem-solving, critical thinking, and employability skills (Vasilev, 2025). At the same time, comparatively lower ratings for identifying student misconceptions (4.00) and linking lessons to real-world applications (4.00) highlight areas for further improvement. These gaps may be linked to institutional barriers such as insufficient engagement with industry, lack of structured feedback systems, and limited curriculum flexibility, which restrict teachers' ability to contextualize lessons in real-world scenarios (Maladona & Ilmiyati, 2025).

Implications for TVET Teacher Development

The results suggest that TVET teachers possess strong competencies across CK, PK, and PCK, and their greatest strength is in integrating content and pedagogy. However, areas such as assessment literacy and demonstration skills remain weaker, largely due to institutional and systemic barriers including resource constraints, traditional evaluation practices, and limited industry collaboration. This resonates with recent scholarship emphasizing the need for continuous professional development that balances theory with practice while incorporating authentic assessment strategies (Zulkarnain et al., 2025). Strengthening teacher training in these domains—through structured workshops, industry immersion, and institutional support for innovative assessment—will enhance individual competence and improve student learning outcomes and industry relevance in TVET programs.

CONCLUSIONS

The study confirms that TVET teachers demonstrate strong competence across Shulman's domains, with PCK emerging as their greatest strength. Teachers excel in integrating pedagogy with content through hands-on, practice-based strategies, reflecting the applied demands of technical-vocational instruction. However, gaps in assessment literacy and practical demonstrations indicate areas requiring focused professional development. Addressing these weaknesses will enhance teacher effectiveness and ensure the production of industry-ready graduates, reinforcing the relevance and competitiveness of TVET programs. Future research could extend these findings by exploring the long-term impact of professional development interventions on teachers' classroom practice and student outcomes.

RECOMMENDATION

Based on the findings, it is recommended that targeted professional development programs be implemented to strengthen TVET teachers' assessment literacy and practical demonstration skills. Training should prioritize authentic and performance-based assessment approaches suited to technical-vocational contexts and opportunities for hands-on practice and peer learning to improve demonstration competence. Institutions may also consider integrating continuous industry immersion and collaboration initiatives to ensure teachers remain

responsive to evolving workplace demands. Finally, future research should evaluate the effectiveness of these interventions through longitudinal and multi-site studies, providing evidence to guide policy and practice in TVET teacher development.

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