

Technology-Pedagogy Gaps in Vocational-Higher Education Digital Innovation

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Abstract—This study investigates the gaps within the Technological Pedagogical Content Knowledge (TPACK) components and digital tool utilization across educators in TVET, and HEI institutions, focusing on innovative pedagogy practices. Utilizing a mixed-methods approach, the research examines how differences in Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Content Knowledge (TCK) impact the effective integration of technology in teaching. The findings reveal significant disparities in specific dimensions of technology's role in transforming course content delivery and contextualizing learning, despite an overall lack of significant differences in general technology use, learner engagement, and problem-solving. These gaps underscore the critical need for targeted professional development programs designed to enhance educators' competency in seamlessly combining technology with pedagogy and content knowledge. Moreover, the study identifies the necessity for systemic interventions and policy alignment, particularly through DepEd-CHED joint guidelines and the Philippine Professional Standards for Teachers (PPST) to provide scalable and sustainable alternatives for bridging these deficiencies. The implications stress that without addressing these professional development gaps, educators may struggle to fully leverage digital tools for innovative and contextually relevant instruction. This research contributes valuable insights for policymakers, institutional leaders, and educational practitioners aiming to advance effective technology integration in Philippine education systems.

Keywords— Digital tools, innovative pedagogy, Kruskal-Wallis test, professional development, TPACK.

I. INTRODUCTION

The Technological Pedagogical Content Knowledge (TPACK) framework integrates technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) to foster innovative teaching and learning in Technical Vocational Education and Training (TVET) and Higher Education Institutions (HEI) (Arifin, Nurtanto, Priatna, Kholifah, & Fawaid, 2020; Salleh, Kadir, Jamaluddin, & Puad, 2022). In these contexts, TPACK enables educators to align general digital tools with practical, skill-based content through blended, student-centered approaches that enhance employability and engagement amid Industry 4.0 and 5.0 demands (Ong, & Annamalai, 2024; Ajani, 2024). Despite its potential, persistent gaps undermine effective utilization of general digital tools for instruction delivery (Derder, Sudaria, & Paglinawan, 2024, superficial integration of technology and pedagogy (TPK) limits transformative practices (Chukwuemeka, 2025); inadequate technological relevance to

content delivery (TCK) mismatches tools with technical subjects (Santos, & Castro, 2021); weak alignment of pedagogy and content (PCK) hampers interactive methods (Smit, Weitzel, Blank, Rietz, Tardent, & Robin, 2017); restricted collaborative and interactive learning stifles group digital activities (Bower, Lee, & Dalgarno, 2017); deficiencies in tech-enhanced feedback, assessment, and continuous improvement hinder data-driven refinements (Manzoor, 2025), particularly with Likert-scale evaluations; and insufficient professional development ecosystems exacerbate disparities in resource-limited settings (Bristol-Alagbariya, Ayanponle, & Ogedengbe, 2024). These issues might affect the early cultivation of critical thinking and inquiry skills of students and mentors (Kingiri, Andersen, & Hanlin, 2024; Auxilio, & Fabela, 2025).

These gaps necessitate targeted research to bridge them, as empirical studies show that robust TPACK correlates with effective general digital tool integration and curriculum relevance in TVET/HEI (Mbatha, 2024; Diao, & Hu, 2022). Addressing them aligns with policy priorities in developing regions (Tallat, Hawbani, Wang, Al-Dubai, Zhao, Liu, & Alsamhi, 2023), such as CHED initiatives for Philippine SUCs, promoting sustainable educator capacity-building (Reyes, Albert, Tabuga, Arboneda, Vizmanos, & Cabaero, 2019; Aldaba, Sescon, & Alconis, 2024). The specific objectives of this study are:

1. To assess instructors' TPACK levels in TVET/HEI using validated surveys, identifying deficiencies in TPK, TCK, and PCK related to general digital tool utilization.
2. To determine whether there are significant differences in the levels of technological pedagogical knowledge (TPK), technological content knowledge (TCK), and pedagogical content knowledge (PCK) among TVET/HEI respondents.
3. To determine professional development gaps and inputs to policy recommendations for sustainable TPACK ecosystems.

Null Hypothesis Statement

Ho: There is no significant difference in the mean TPACK levels (TPK, TCK, PCK) among TVET and HEI mentors regarding general digital tool utilization for innovative teaching and learning.

II. LITERATURE REVIEW

The TPACK framework highlights persistent gaps between technological capabilities, pedagogical strategies, and content

delivery in TVET and higher education, impeding digital innovation amid Industry 4.0 demands. Systematic reviews reveal TVET digitalization challenges, including educator competency deficits, curriculum misalignment with digital skills, and infrastructure inequities, which exacerbate employability mismatches (Drugova, Zhuravleva, Aiusheeva, & Grits, 2021; Alinea, 2022; Kholid, Hendriyanto, Sahara, Muhaimin, Juandi, Sujadi, & Adnan, 2023; Othman, Omar, Majid, 2025).

Educators exhibit moderate TPACK proficiency, particularly in TPK and TCK, limiting transformation from substitution-level tech use (e.g., basic LMS) to redefinition (e.g., AI-personalized learning). In higher education, faculty development programs often fail to integrate disciplinary content with technology, constrained by time, motivation, and institutional support. Vocational contexts face amplified barriers like resource scarcity and transversal skill shortages, widening industry-TVET gaps (Drugova et al, 2021; Kholid et al, 2023; Othman et al 2025).

Instructors demonstrate the lowest proficiency in TK, marked by limited familiarity with digital tools (e.g., simulations, VR) and inadequate integration into vocational teaching. Vocational centers report significantly lower TK than secondary schools ($p=0.01$), linked to infrastructure deficits. Moderate overall TPACK stems from TK gaps, hindering effective tech use (Nepembe, & Simuja, 2023). TCK ranks low, with instructors struggling to select technologies suited to vocational content (e.g., engineering simulations) due to framework limitations in guidance. Pre-service teachers show moderate TCK but prioritize it over TPK, yet application remains suboptimal in practice (Masfuah, Fakhriyah, Hilyana, & Kiong, 2024). Instructors lack training in digital tools, limiting pedagogical transformation from traditional to tech-enhanced methods like AI or blended learning. Studies note gaps between instructor capabilities and Industry 4.0 requirements, affecting teaching quality (Al Shuaili, 2025).

These gaps hinder innovative practices, such as analytics-driven pedagogy, with studies recommending contextual PD models combining TPACK training and SAMR evaluation. Philippine Region 10 parallels global findings, underscoring needs for localized interventions (Suarman, Isjoni, Sumarno, & Fikri, 2025; Othman et al, 2025)

III. METHODOLOGY

A. Research Design

This study employs a sequential explanatory mixed-methods design to assess TPACK perceptions (Ali, & Hawk, 2024) and bridge identified gaps in general digital tool utilization for innovative teaching in TVET and HEI (Rajamanickam, Che'Rus, Raji, Mina, & Vebrianto, 2024). Quantitative data from surveys quantify instructors' TPACK levels (Chai, Koh, & Tsai, 2016), followed by qualitative interviews to explain deficiencies and inform interventions (Nastasi, & Schensul, 2005). This approach aligns with TPACK research in vocational contexts, enabling comprehensive gap analysis and objective-driven solutions.

B. Participants and Sampling

Participants include 30 instructors from TVET institutions and HEIs in Southern Philippines, such as faculty in DepEd, TESDA, and SUCs, selected via stratified purposive sampling to represent technical fields like engineering and technology education (Daniel, 2021). Inclusion criteria encompass full-time faculty with at least two years of experience using general digital tools (Watts, & Robertson, 2011). Sample size supports nonparametric analyses for Likert-scale data, drawing from the researcher's prior small-sample expertise (Guerra, Gidel, & Vezzetti, 2016). Each item is prefaced by the Likert scale text as follows:

	Scale Range:	
1 – Strongly Disagree		1.4 – below
2 – Disagree		1.5 – 2.4
3 – Neutral		2.5 – 3.4
4 – Agree		3.5 – 4.4
5 – Strongly Agree		4.5 – above

IV. RESULTS AND FINDINGS

A. Assessment of TPACK

Technological Pedagogical Knowledge (TPK) refers to educators' understanding of how various technologies can alter and enhance pedagogical practices to support effective teaching and learning processes (Ratnaya, Hunaepi, Wardani, & Sukiastini, 2024). It emphasizes the affordances and constraints of digital tools in facilitating instructional strategies, independent of specific content areas. Educators with strong TPK demonstrate the ability to select and apply general digital tools to design dynamic teaching-learning environments that promote active engagement and knowledge construction. Expectations include adapting pedagogy to technology's capabilities, such as shifting.

Table 1 shows the summary of mean ratings on TPK as perceived by respondents from DepEd, TESDA, and HEI in Southern Philippines, which measures knowledge and ability to use technology for effective pedagogy, including designing and supporting teaching-learning processes. The mean responses across all respondents yielded Strong Agreement (mean range of 4.5 above) in all parameters except for parameters on digital tool integration, adaptation, and collaborative & interactivity, which fall in the agreement scale (mean range of 4.2 to 4.4) in TESDA and HEI, which run in contrast with DepEd's Strong Agreement. The unlikely difference may be attributed to the levels of enabling technologies utilized in the HEIs, which may be classified into more complex digital tools utilized in TESDA and HEI, compared to those used in basic education.

DepEd educators show higher regard for digital tool utilization than TESDA and HEI counterparts due to structured national programs like the Digital Rise Program, which prioritizes basic, accessible tools (e.g., DepEd Commons, LMS, DepEd TV/RBI) for mass deployment in K-12 blended learning and digital literacy. This policy-driven focus enables widespread adoption despite infrastructure limitations, contrasting with TESDA/HEI's emphasis on specialized, industry-aligned tools. The disparity stems from

digital tool complexity: DepEd employs simple platforms suited to foundational pedagogy and broad accessibility, boosting confidence and utilization rates. Conversely, TESDA/HEI rely on complex tools (e.g., VR simulations for TVET skills, advanced LMS in higher education), requiring substantial infrastructure, training, and TCK/TPK integration, exacerbating gaps and lowering perceived utilization. DepEd's simplicity fosters efficacy, while TESDA/HEI complexity signals urgent PD needs.

TABLE 1. The summary of mean responses on technological pedagogical knowledge (TPK)

Parameter	DepEd		TESDA		HEI	
	SD	M	SD	M	SD	M
1. I can integrate digital tools and technologies to enhance teaching and learning strategies.	.51	4.6	.45	4.2	.55	4.4
2. I adapt technology to suit different instructional approaches and student needs.	.64	4.5	.55	4.4	.55	4.6
3. I am aware of how technology can facilitate collaborative and interactive learning experiences.	.52	4.5	.55	4.4	.45	4.8
4. I seek opportunities to innovate classroom practices using available technologies.	.52	4.5	.89	4.6	.55	4.6
5. I support or participate in professional development on technology-enhanced pedagogy.	.52	4.5	.55	4.6	.45	4.8

Technological Content Knowledge (TCK) refers to educators' understanding of how technology influences and reshapes the representation, conceptualization, and advancement of discipline-specific content knowledge (Njiku, Mutarutinya, & Maniraho, 2020). It focuses on the interplay where digital tools either enhance or constrain subject matter delivery, enabling new ways to explore complex concepts beyond traditional methods. Educators proficient in TCK select and apply technologies that align with content demands, such as using simulations to model discipline-specific processes or data visualization for abstract theories. Mentors anticipate how tools transform content affordances like, dynamic modeling software revealing relationships in engineering principles previously limited by static diagrams.

Table 2 summarizes the average responses on TCK, which measures understanding of how technology relates to and enhances discipline-specific content knowledge. Respondents from DepEd showed Strong Agreement across all parameters regarding the impact of technology tools used in instruction at the basic education level. TESDA, on the other hand, rated within the Agreement scale with a mean rating of 4.0 to 4.2, possibly due to the conservative training regulation practices of the institution. HEI respondents also showed Strong Agreement on all parameters, except for the use of discipline-specific digital tools and updated equipment in instruction, which fell within the Agree scale—likely due to outdated

equipment.

TABLE 2. The summary of mean responses on technological content knowledge (TCK)

Parameter	DepEd		TESDA		HEI	
	SD	M	SD	M	SD	M
1. I understand how technological tools transform the way content is presented and delivered.	.51	4.6	.45	4.2	.00	5.0
2. I use technology to make subject matter more accessible and engaging for learners.	.51	4.7	.45	4.2	.55	4.6
3. I apply digital resources to address discipline-specific challenges or problems.	.51	4.6	.00	4.0	.55	4.4
4. I am updated with industry-based technological standards relevant to my field's content.	.63	4.4	.45	4.2	.55	4.4
5. I encourage or observe the use of technology to contextualize learning within real-world scenarios.	.49	4.7	.00	4.0	.00	5.0

Pedagogical Content Knowledge (PCK) represents educators' ability to transform subject matter into accessible forms using strategies tailored to the discipline's unique demands and learners' needs (Vettriselvan, Rajesh, Subhashini, Gajalakshmi, & Sakthivel, 2025). It integrates content expertise with pedagogical methods to address common misconceptions and facilitate comprehension. Educators with strong PCK select discipline-specific representations, such as analogies for abstract engineering concepts or hands-on models for vocational skills, to make content comprehensible. Mentors anticipate learner challenges, adapting strategies like scaffolding or questioning to promote deep understanding rather than rote memorization. Expectations include knowledge of students' prior conceptions, curriculum contexts, and effective assessment techniques suited to the subject.

Table 3 displays the summary of mean responses on PCK, which focuses on the ability to teach or support subject matter effectively, using pedagogical strategies suited to the discipline. DepEd's responses revealed Strong Agreement across all parameters except for the instructional strategies design, which fell on the Agreement scale (mean = 4.4). TESDA's responses are within the Agreement scale range, with mean ratings from 3.8 to 4.4. HEIs are in the Agreement to Strongly Agree scale range with 4.0 to 5.0, noting some shortfalls in instructional design, pedagogical approaches, and assessment result adjustments.

B. The Test for Significant Difference

In the current study, the Kruskal-Wallis test was utilized due to the nature of the data and study design. The dependent variable was measured using an ordinal 5-point Likert scale, which represents ordered categories rather than continuous interval data. Since the assumptions of parametric tests like

one-way ANOVA, including normality and homogeneity of variance, may not hold for ordinal data, a nonparametric method was more appropriate. The Kruskal-Wallis test does not require normally distributed data and can effectively compare three or more independent groups by analyzing their ranked scores. This makes it suitable for detecting significant differences across the educator groups (DepEd, TESDA, HEI) based on their ordinal ratings, providing a robust and valid analysis approach for such data.

TABLE 3. The summary of mean responses on pedagogical content knowledge (PCK)

Parameter	DepEd		TESDA		HEI	
	SD	M	SD	M	SD	M
1. I select appropriate teaching methods to communicate discipline-specific concepts clearly.	.52	4.5	.89	4.4	.55	4.6
2. I design learning activities that effectively combine instructional strategies with content requirements.	.63	4.4	.84	4.2	.45	4.2
3. I address misconceptions and difficulties unique to the subject matter through pedagogical approaches.	.64	4.5	.45	3.8	.00	4.0
4. I adapt instruction based on assessment results related to the content being taught.	.51	4.6	.00	4.0	.55	4.4
5. I support, promote, or participate in curriculum innovation to improve how content is taught and learned.	.46	4.7	.55	4.4	.00	5.0

Table 4 summarizes the Kruskal-Wallis test results for Technological Pedagogical Knowledge (TPK) interplay across Technology, Pedagogy, Knowledge, and their combined effects, revealing p-values substantially exceeding 0.05 for all parameters. These non-significant findings indicate no statistically meaningful differences in distributions or medians among DepEd, TESDA, and HEI groups, failing to reject the null hypothesis of uniformity. This uniformity suggests consistent perceptions of TPK integration within the sample, potentially reflecting shared foundational competencies rather than measurable gaps in these educational components.

Table 5 summarizes Kruskal-Wallis test results examining the interplay of technology, content, and knowledge across DepEd, TESDA, and HEI groups. Parameters such as technology facilitating subject accessibility, engaging learners, addressing problems, and updating trends showed p-values well above 0.05, indicating no statistically significant differences in rank distributions among groups and supporting the null hypothesis of uniformity. However, digital tools transforming course content delivery ($p = .041^*$) and enabling tools contextualizing learning ($p = .005^*$) yielded significant results below the 0.05 threshold, rejecting the null hypothesis and revealing group-specific disparities in these TCK-focused areas. These findings highlight targeted intervention needs amid overall consistency.

TABLE 4. Summary of Kruskal-Wallis Test on TPK

Parameters	Kruskal-Wallis (χ^2)	Probability (p)
1. I can integrate digital tools and technologies to enhance teaching and learning strategies.	2.46	.292
2. I adapt technology to suit different instructional approaches and student needs.	.45	.798
3. I am aware of how technology can facilitate collaborative and interactive learning experiences.	1.66	.436
4. I seek opportunities to innovate classroom practices using available technologies.	.839	.657
5. I support or participate in professional development on technology-enhanced pedagogy.	1.067	.587

$P < .05$ $df=2$

TABLE 5. Summary of Kruskal-Wallis Test on TCK

Parameters	Kruskal-Wallis (χ^2)	Probability (p)
1. I understand how technological tools transform the way content is presented and delivered.	6.4	.041*
2. I use technology to make subject matter more accessible and engaging for learners.	3.2	.200
3. I apply digital resources to address discipline-specific challenges or problems.	5.3	.071
4. I am updated with industry-based technological standards relevant to my field's content.	.68	.713
5. I encourage or observe the use of technology to contextualize learning within real-world scenarios.	10.7	.005*

$p < .05$ $df=2$

The parameters related to transforming course content delivery and contextualizing learning with digital tools likely yielded p-values below 0.05 because DepEd, TESDA, and HEIs experience unequal infrastructure, access, and sector-specific curricular demands, leading to genuinely different opportunities to use advanced technologies in content redesign. These differences are reinforced by uneven TCK/TPK-focused professional development and distinct policy pressures, with DepEd prioritizing broad access through basic tools and TESDA/HEIs pushed toward more complex, industry-aligned technologies. As a result, educators' perceptions of how strongly digital tools transform content and contextualize learning diverge across sectors, producing statistically significant group differences for these higher-order technology-content parameters.

Table 6 presents a summary of the Kruskal-Wallis test results examining the interplay of pedagogy, content, and knowledge. The analyses for parameters such as appropriateness of teaching methods, learning activities with instructional strategies, adaptation of instruction based on assessment results, and promoting curriculum innovation yielded p-values well above the 0.05 threshold, indicating no statistically significant differences or associations across the groups tested. However, in the context of how misconceptions and difficulties were addressed accordingly, the test yielded

significant results with p-values of .024*. This p-value is below the 0.05 significance level, indicating significant differences between groups in these specific areas and thus leading to the rejection of the null hypothesis for this parameter.

TABLE 6. Summary of Kruskal-Wallis Test on PCK

Parameters	Kruskal-Wallis (χ^2)	Probability (p)
1. I select appropriate teaching methods to communicate discipline-specific concepts clearly.	.23	.892
2. I design learning activities that effectively combine instructional strategies with content requirements.	.69	.708
3. I address misconceptions and difficulties unique to the subject matter through pedagogical approaches.	7.46	.024*
4. I adapt instruction based on assessment results related to the content being taught.	5.30	.071
5. I support, promote, or participate in curriculum innovation to improve how content is taught and learned.	4.32	.115

$P < .05$ $df=2$

The parameter “I address misconceptions and difficulties unique to the subject matter through pedagogical approaches” likely yielded a p-value below 0.05 because DepEd, TESDA, and HEI educators differ markedly in the depth of their pedagogical content knowledge, assessment practices, and exposure to PD focused on diagnosing and remediating learner errors. Basic education teachers tend to receive more structured training and support for addressing misconceptions, while many TVET and HEI instructors rely more on technical expertise and performance-based assessment, producing significantly divergent perceptions and practices across sectors.

C. The Professional Development Gaps

Based on a focus group discussion (FGD) involving teachers, trainers, and educators, it was collectively recognized that addressing inadequacies in innovative teaching and learning requires targeted professional development initiatives grounded in the integration of Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Pedagogical Content Knowledge (PCK).

Table 7 presents a summary of professional development gaps and their corresponding evidence collectively identified by the FGD participants. Participants emphasized that professional growth programs must move beyond isolated technology training to cultivate educators’ holistic ability to seamlessly blend technology with pedagogy and content knowledge. This collaborative insight highlights the urgent need for continuous, context-driven, and practice-oriented development opportunities that build educators’ confidence and competence in deploying digital tools and innovative instructional strategies effectively. These focus group findings serve as a foundational guide for designing professional development that truly responds to educators’ real-world challenges and aspirations in enhancing teaching and learning

innovation. The following professional development inputs to future initiatives are noteworthy to consider:

TABLE 7. Summary of TPACK professional development gaps

TPACK Component	Key PD Gaps	Evidence
TPK (Technology-Pedagogy)	Insufficient hands-on training for digital tool integration into pedagogical processes; superficial vs. transformative use.	Lack of sustained peer coaching and micro-credentials.
TCK (Technology-Content)	Limited discipline-specific modules for tool-content synergy; no action research for evaluation.	Absence of simulations reshaping technical representations.
PCK (Pedagogy-Content)	Inadequate learner-centered strategies for technical misconceptions; shortage of mentoring/reflective practices.	Weak alignment without technology focus.
Integrated TPACK	One-off workshops vs. longitudinal/blended programs; weak infrastructure/follow-up.	No communities of practice or pre/post assessments.

- i. Professional Development Needs for TPK Inadequacies
To bridge gaps in Technological Pedagogical Knowledge (TPK), professional development (PD) must emphasize hands-on training in integrating general digital tools with pedagogical strategies for active learning processes. Key needs include workshops on designing tech-enhanced lesson plans, micro-credential programs for tool affordances, and peer coaching to adapt pedagogy dynamically. These interventions foster skills in supporting collaborative and interactive environments, addressing superficial tech use in DepEd/TVET/HEI.
- ii. Professional Development Needs for TCK Inadequacies
For Technological Content Knowledge (TCK), PD requires discipline-specific modules showing how digital tools reshape subject representations, such as simulations for technical concepts. Potent strategies encompass content-focused tech labs, online courses blending tools with curriculum standards, and action research projects to evaluate tool-content synergy. Such training counters mismatches in vocational delivery, enhancing relevance without pedagogy overload.
- iii. Professional Development Needs for PCK Inadequacies
Pedagogical Content Knowledge (PCK) gaps demand PD centered on learner-centered strategies tailored to technical disciplines, like case-based seminars on misconceptions in skill-based subjects. Effective needs include mentoring programs, reflective portfolios, and interdisciplinary PD linking content expertise with adaptive teaching methods. These build foundational alignment, preparing instructors for TPACK integration in resource-limited DepEd/HEI/TVET settings.

D. The Inputs to Policy Recommendations

To effectively address the identified gaps in Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Pedagogical Content Knowledge (PCK), systemic interventions are necessary to provide potent and sustainable alternatives. These interventions should be

guided by evidence-based policy recommendations that emphasize comprehensive support for educators, including resource allocation, targeted professional development, infrastructural improvements, and institutional frameworks that foster integrated technology-enhanced teaching and learning practices aligned with current educational demands.

Table 8 shows the key policy inputs derived from empirical research emphasize systemic interventions for TPK,

TCK, PCK, and integrated TPACK in DepEd/TVET/HEI, particularly in the context of developing the Philippine education and training. The policy recommendations are anchored on sustainable hands-on tech-pedagogy, coaching, and micro-credentials advocacy; promote TPACK-based programs and internships; and foster TPACK infrastructure investments, assessment, and sustainable development.

TABLE 8. Key inputs for policy recommendations

TPACK Component	Key Policy Recommendations	Supporting Evidence
TPK(Technology-Pedagogy)	Mandate sustained PD programs with hands-on tech-pedagogy workshops and peer coaching; allocate budgets for micro-credentials in active learning integration.	Emphasize systematic mentoring between novice/experienced teachers
TCK(Technology-Content)	Require discipline-specific TPACK modules in curricula, including action research grants for tool-content synergy evaluation.	Provide TVET training programs aligned with lifelong learning
PCK(Pedagogy-Content)	Integrate learner-centered PCK training into pre-service programs with field internships emphasizing technical misconceptions.	Align with the Philippine Professional Standards for Teachers (PPST) via DepEd-CHED joint policies for experiential teaching
Integrated TPACK	Establish national TPACK frameworks with infrastructure investments, longitudinal PD, and evaluation metrics (pre/post assessments); incentivize communities of practice.	Invest in technical knowledge, admin training, and outcome tracking

TABLE 9. Major Themes, Guide Questions, and Illustrative Quotes from TPACK PD Analysis

Theme / Code	Guiding Question	Illustrative Quote
TPK – Hands-on integration	1. When you integrate digital tools into your teaching, how do they change the way you organize and conduct your lessons?	“When I use digital tools, I break the lesson into interactive segments with simulations, quick polls, and debriefing, so my role shifts from lecturer to learning facilitator.”
TPK – Effective tech-enhanced pedagogy	2. Describe a recent lesson where you felt technology truly enhanced student engagement or understanding. What made it effective pedagogically?	“In a recent lesson, using an interactive simulation turned a normally passive discussion into a problem-solving session where students tested their ideas in real time, and the immediate visual feedback helped them grasp the concept much faster.”
TCK – Current tech-content use	3. How do you currently use digital tools to represent or explain key concepts in your discipline (e.g., processes, procedures, abstract ideas)?	“For complex processes, I rely on short animations and step-by-step screen recordings so learners can pause, replay, and visualize each stage, which is much harder to achieve with static diagrams alone.”
TCK – PD needs for content-tool fit	4. What kinds of professional development or resources would help you better connect specific technologies with the unique content of your field?	“I need discipline-specific examples that show which tools work best for the particular procedures and abstract concepts in my field, instead of generic ICT sessions that treat all subjects as the same.”
PCK – Teaching difficult topics	5. Think of a topic in your discipline that students usually find difficult. How do you normally teach it, and what strategies help address common misconceptions?	“When I teach a topic that students usually find difficult, I start by surfacing their misconceptions through quick questions, then use concrete analogies and scaffolded practice tasks to slowly rebuild their understanding.”
PCK – Mentoring and reflection	6. What kinds of mentoring, coaching, or reflective activities (e.g., lesson study, peer observation, teaching portfolios) would best support you in improving how you teach your subject?	“Regular lesson study cycles where we co-plan, observe each other, and reflect with a mentor would help me see how other teachers handle tricky topics in our subject and refine my own approaches.”
Integrated TPACK – Planning process	7. When you plan a technology-enhanced lesson, how do you think about the relationships among content, pedagogy, and technology? Please walk through your planning process.	“When I plan a technology-enhanced lesson, I first clarify the exact concept students must master, then decide which pedagogy will make them think deeply, and only after that do I choose a tool that genuinely supports that strategy.”
Integrated TPACK – Successful/failed cases	8. Describe an experience where these three elements (content, pedagogy, technology) worked together very well—or did not work well—in your class. What factors contributed to that outcome?	“In one successful class, a well-chosen simulation, guided inquiry questions, and targeted feedback aligned perfectly, and students could explain the concept in their own words; in another, I used technology without adjusting my pedagogy, and it just added noise instead of clarity.”
PD Experience – Helpfulness of past PD	9. Looking back at the professional development you have received on technology integration, what aspects were most helpful, and why? What was least helpful, and why?	“The most helpful PD let us practice with tools on our own lessons and then follow up after implementation; the least helpful were lecture-style sessions about apps that we never had time or support to actually use.”
PD Design – Ideal program	10. If you could design your own ideal professional development program for innovative, technology-enhanced teaching, what would it look like (duration, format, activities, and assessment)?	“My ideal PD would run over a semester in blended format, combining short online modules, coached lesson design, classroom implementation, peer observation, and a portfolio that documents how my teaching and student learning changed.”
Institutional Policy – Influence on Practice	11. How do current institutional policies, requirements, or expectations influence the way you use technology in teaching? Please give examples.	“Institutional requirements to document technology use in lesson plans push me to include digital tools, but policies rarely consider actual learning impact, so sometimes I feel pressured to ‘tick the box’ rather than innovate meaningfully.”
Institutional Support – Needed enablers	12. What forms of institutional support (infrastructure, recognition, workload allocation, leadership) would most strongly encourage you to experiment with and sustain TPACK-aligned practices?	“Reliable infrastructure, protected time in my workload for experimentation, and formal recognition of innovative teaching would strongly encourage me to sustain TPACK-aligned practices.”
Policy Recommendations – Desired changes	13. If you could propose one or two policy changes at the department, college, or national level to better support innovative, technology-enhanced teaching, what would they be, and why?	“If I could recommend changes, I would call for funded, long-term TPACK-oriented PD tied to clear standards and for policies that reduce non-teaching workload, so educators have the time and support to design and refine technology-enhanced instruction.”

Table 9 shows that the open-ended guided questions by thematic parameter are crucial in establishing the qualitative dimension of the present study because they capture the nuanced experiences, explanations, and contextual factors that numeric ratings alone cannot reveal. By structuring these prompts around core themes such as TPK, TCK, PCK, and professional development needs, the questions elicit rich narratives that help explain why quantitative differences emerged, thereby deepening interpretation, validating survey results, and generating grounded inputs for targeted interventions and policy recommendations.

V. CONCLUSIONS

Kruskal-Wallis analysis reveal uniform TPACK interplay across DepEd, TESDA, and HEI groups ($p > 0.05$) for most parameters, indicating consistent foundational competencies but requiring larger samples to detect subtler effects. Targeted disparities emerge in TCK content transformation ($p = 0.041$), learning contextualization ($p = 0.005$), and PCK misconception resolution ($p = 0.024$), highlighting precise intervention areas for digital tool mastery and pedagogical problem-solving.

Professional development must address TCK/TPK/PCK gaps through sustained, PPST-aligned programs, hands-on simulations, lesson study cycles, and discipline-specific modules, transforming statistical uniformity and sectoral insights into systemic innovation capacity across Southern Philippines vocational-higher education.

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