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Beyond the PowerPoint Classroom: Nursing Students' Experiences of a TPACK-Informed Learning Environment

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Abstract
A mixed-methods sequential explanatory study examined nursing students' experiences of a learning environment across three Maldivian nursing institutes. Aim to identify how TPACK-designed lessons redesign shaped students' learning experiences and to interpret these experiences through TPACK-in-context model. Paired outcome data (N=63) showed a significant score increase (73.46 to 88.70, p<.001). Followed by thematic analysis done with 26 students through focus group discussions and revealed alignment among content, pedagogy, and nursing content with a context-responsive learning environment. TPACK-informed teaching functions best as context-responsive learning-environment redesign, extending TPACK-XK toward a proposed TPACK-N framework for nursing education.
Keywords: TPACK; Learning Environment; Student Nurse; Lesson redesign

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1.0 Introduction

This study utilises the concept of the Technological Pedagogical Content Knowledge (TPACK) model to integrate technology through the interaction of technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK), together with TPK, TCK, PCK and the integrative TPACK domain (Koehler & Mishra, 2009; Mishra & Koehler, 2006). Petko, Mishra, and Koehler (2025) further expand on updating the TPACK model to emphasis that external context and Contextual Knowledge (XK) can shape educator practice. The educational environment informs TPACK, while XK covers educators' understanding of settings, technologies, policies, and learners.

In nursing education, pedagogy to deliver the lessons, technology enhances teaching and learning must be integrated. In addition, XK component connects theoretical knowledge with clinical reasoning, psychomotor performance, communication, professional values and patient safety and connect to the extended environment.

Extending the literature on prospective nursing educators had stronger pedagogical and content knowledge than technology integrated knowledge (Ait Ali et al., 2023). This is especially relevant in nursing, where various environments converge, making contextual awareness crucial for effective teaching. Stronger evidence from nurse educator studies identifies continuing development needs in

digital pedagogy, safe and responsible technology use, and evidence-based guidance for learning (Pajari et al., 2024; Shon et al., 2024). In addition, heterogeneous digital competence profiles associated with pedagogical preparation, experience and interest in educational technology (Pajari et al., 2025a, 2025b). Thus leads to context-sensitive digital competence.
The present paper, therefore, shifts the emphasis away from the question of whether technology alone improves student performance. Instead, it asks how TPACK-informed lesson redesign can be understood as a redesign of the nursing learning environment and how students experience that environment. It integrates a concise quantitative outcome signal with the qualitative explanatory strand of a larger sequential explanatory mixed-methods study.

1.1 Aim and research question
The purpose of this explanatory sequential mixed-methods study is to first evaluate the effectiveness of TPACK-redesigned teaching on nursing students' learning by collecting gain-score from pre and post intervention data from their assessment scores and then follow up with qualitative interviews to explain those statistical results by exploring the participants' detailed experiences following implementation of TPACK-designed teaching within the nursing educational environment.

1.2 The specific 3 objectives are to:
(1) Quantitative phase: To measure the student learning outcome through their test score using their gain-score..
(2) Qualitative phase: To understand how students perceived the alignment of content, pedagogy, technology and clinical practice within that environment; describe nursing students' experiences within the redesigned, TPACK-informed learning environment
(3) Integration phase: Interpret the combined findings through the lens of the updated TPACK-in-context model, explicitly separating external contextual factors from the educators' Contextual Knowledge (XK).

2.0 Literature Review

2.1 Theoretical Foundations: TPACK in Nursing Student Learning Environments
The design of effective student learning environments in nursing education requires a multi-faceted synthesis of theoretical knowledge, psychomotor skill acquisition, and clinical decision-making. Historically, technology integration in healthcare education was treated as an auxiliary media delivery tool, frequently isolated from core instructional design. To address this limitation, Mishra and Koehler (2006) introduced the Technological Pedagogical Content Knowledge (TPACK) framework, thus expanding Shulman's pedagogical content knowledge to demonstrate how technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) dynamically intersect (Koehler & Mishra, 2009). It is evident within nursing student learning environments, foundational TPACK literature establishes that digital tools cannot enhance learning outcomes on their own but depend on educational efficacy and pedagogical alignment with complex clinical content and real-world care scenarios (Koehler & Mishra, 2009; Mishra & Koehler, 2006).
As Figure 1 shows, the conceptual application retains the integrity of Petko et al's (2025) updated framework, in which external context is not treated as an eighth knowledge domain. Rather, the external nursing educational context shapes the development and enactment of TPACK, while XK represents the educator's knowledge about that environment. Hence, this paper focuses on external context, which includes curriculum, learner characteristics, accessibility, classroom and skills-laboratory conditions, clinical expectations and available technologies. XK includes educators' understanding of these conditions and their capacity to use that understanding when aligning technology, pedagogy and nursing content.

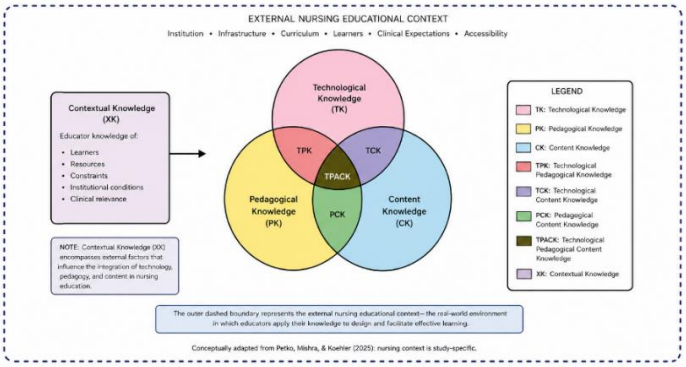

Figure 1 Conceptual application of the updated TPACK-in-context model to the nursing educational environment

Source: Original study-specific schematic informed by Petko, Mishra, and Koehler (2025); it is not a reproduction of their published figure.

2.1 Digital Learning Modalities and Student Outcomes in Nursing Environments
There is a rapid evolution of technology-enhanced learning environments incorporating extended reality (XR), virtual reality (VR) simulations, serious gaming, and interactive digital platforms that have fundamentally altered nursing pedagogy (Byrne, 2026; Choi et al., 2022; Plotzky et al., 2021). A robust body of contemporary synthesis and empirical research confirms that technology-integrated learning environments significantly improve nursing students' knowledge acquisition, clinical reasoning, psychomotor performance, and overall engagement (Kim & Shin, 2023; Li et al., 2024; Min et al., 2022; Mulyadi et al., 2021; Özdemir & Dinç, 2022; Tavares, 2022;

Woon et al., 2021). Immersive VR and simulation environments provide students with safe, low-anxiety spaces to practice high-stakes clinical decision-making without risking patient safety (Kim & Shin, 2023; Mulyadi et al., 2021; Tavares, 2022). However, recent systematic reviews emphasise that high-tech environments do not automatically provide superior learning gains; educational success remains contingent on how effectively digital modalities are embedded in active learning strategies, authentic clinical contexts, and structured debriefing (Choi et al., 2022; Li et al., 2024).

2.2 Educator TPACK, Contextual Knowledge (XK), and Environmental Optimization Digital Learning Modalities and Student Outcomes in Nursing Environments

Optimising the student learning environment depends directly on the digital and pedagogical competence of nurse educators. From a global perspective, empirical studies demonstrate that while faculty possess advanced clinical expertise and strong pedagogical grounding, their skills in integrating technology remain a significant area for growth (Ait Ali et al., 2023; Pajari et al., 2024, 2025a, 2025b). Addressing this gap requires targeted, TPACK-based faculty development programs that empower educators to scaffold learning effectively across physical classrooms, simulation laboratories, and clinical practice placements (Pajari et al., 2024; Shon et al., 2024). Furthermore, Petko et al. (2025) expanded the classic framework to incorporate Contextual Knowledge (XK) explicitly, recognising that learning environments are constrained and shaped by institutional infrastructure, clinical practice norms, and evolving learner fluencies across generational cohorts (Höfrová et al., 2024). Applying XK within TPACK enables nurse educators to dynamically adapt instructional technology to specific environmental constraints and clinical safety guidelines, transforming digital spaces into responsive, high-impact nursing learning environments (Grünleitner et al., 2026; Petko et al., 2025).

3.0 Methods

3.1 Design and setting

This paper reports the student-focused explanatory component of a larger sequential explanatory mixed-methods study conducted in nursing education in the Maldives. The broader study developed and implemented a TPACK teaching module for nurse educators. For the present paper, quantitative findings are intentionally limited to a concise outcome signal and are integrated with the subsequent qualitative strand. A separate manuscript reports the detailed quantitative analysis of student outcomes; the present paper's distinct contribution is the TPACK-in-context conceptualisation and mixed-methods interpretation of the nursing learning environment. Quantitative data were collected from 63 students using questionnaires, while qualitative data were collected from 26 students through focus group discussions (FGDs) until data saturation. All students participated with informed written consent, and no conflict of interest was present during the period of this study.

3.2 TPACK-informed educational intervention

Nurse educators received structured preparation in TPACK and redesigned existing lessons by aligning learning objectives, nursing content, pedagogical strategies, educational technologies, student learning activities and assessment. The intervention did not prescribe a single technology. Instead, educators selected technologies according to pedagogical purpose, content and contextual requirements. Students therefore experienced TPACK indirectly through redesigned teaching rather than receiving instruction about TPACK itself.

3.3 Quantitative component

Paired learning-outcome data were available for 63 nursing students. The sample included students from Master's (n=10, 15.9%), degree (n=17, 27.0%), diploma (n=21, 33.3%) and advanced-certificate (n=15, 23.8%) programmes. Pre-intervention scores approximated normality (Shapiro–Wilk W=.971, p=.148); gain scores were also approximately normal (W=.970, p=.134). A paired-samples t test was used for the pre/post comparison. Only key statistics required for mixed-method integration are presented.

3.4 Qualitative component

Four student focus groups were conducted after implementation, involving 26 students (codes ST01–ST26). Transcripts were coded independently by two members of the research team using an inductive thematic approach; codes and emerging themes were compared and discrepancies resolved through discussion until consensus was reached. No new codes emerged from the final focus group, indicating that data collection reached saturation. The analysis focused on alignment of student experiences with the study intervention. Focus group discussion moderation and data verification were done, followed by thematic analysis.

3.5 Mixed-method integration

Integration occurred at interpretation. The quantitative strand established the direction and magnitude of change, while the qualitative strand explained how students experienced the redesigned learning environment. This explanatory function is central to the paper and differentiates it from the separately submitted quantitative outcomes manuscript.

4. Results

4.1 Concise quantitative outcome

Student scores presented in table 1 increased substantially following implementation. As seen the paired score for the 63 students both intervention and control group have a mean increase in knowledge gain score of +15.24 and P value indicating a significance, thus resulting a positive outcome of learning.

Table 1. Key quantitative outcome used for mixed-method integration

Outcome	Pre-intervention	Post-intervention	Mean change	Paired comparison
Student score (*N*=63)	73.46 (*SD* 7.09)	88.70 (*SD* 7.49)	+15.24	*t*(62)=-33.60, p<.001

4.2 Student experiences of the TPACK-informed learning environment

Students share their experiences, table 2 present the qualitative themes interpreted through their FGD.

Table 2. Qualitative themes interpreted through TPACK-in-context.

Theme	Interpretive focus	Illustrative evidence	TPACK-in-context link
Meaningful alignment and authenticity	Resources; objectives, content–assessment alignment; academic and nursing relevance	Students identified stronger learning when resources and activities matched expected learning and practice.	CK–PK–TK decisions respond to disciplinary and clinical context.
Active, visual and experiential learning	Visual aids, demonstrations, interaction and experiential strategies	Students preferred approaches that helped them see, discuss, practice and connect concepts not just teach from PowerPoint presentations.	Technology gains value through purposeful pedagogical alignment.
TPACK-integrated teaching enhanced interaction and learning	Purposeful technology integration; engagement; peer-supported participation	"I like when teacher integrate technology in class." (ST13)	Technology is positive when it supports pedagogy, participation and content understanding.
Integration of content, pedagogy and technology	Selection of digital tools according to learning purpose	"Biodigital apps." (ST22); "Teach using technology effectively." (ST24)	Reflects integrated rather than technology-only logic.
Supportive, well-organised learning environments	Digital expectations, generational differences, flexible learning needs	"Sometimes we teach them how to do stuff." (ST26); "Age gap perspective is there but can manage well now." (ST25)	XK includes learner practices, roles, resources and constraints.

4.2.1 Meaningful alignment and authenticity

Students' accounts emphasised coherence among what was taught, how it was taught, what resources were used, how learning was assessed and how classroom learning related to nursing practice. This theme locates technology inside a broader instructional system rather than treating it as an isolated intervention.

4.2.2 Active, visual and experiential learning

Students valued active and visual approaches that supported understanding and participation. Their accounts indicated that engagement was linked to pedagogy and learning activity, not simply to the presence of a digital device or platform.

4.2.3 TPACK-integrated teaching enhanced interaction and learning

Students described technology-integrated lessons as more interactive when technology supported participation and understanding. ST13 stated, "I like when teacher integrate technology in class." The significance is not technology preference alone; it reflects a learning environment in which technology was experienced as part of the teaching process.

4.2.4 Integration of content, pedagogy and technology

Students identified specific digital possibilities, including "Bio digital apps" (ST22), while also articulating the need to "Teach using technology effectively" (ST24). Together, these accounts distinguish technology availability from effective technology integration.

4.2.5 Supportive and context-responsive learning environments

The data also revealed changing educator–student technology relationships. ST26 observed, "Sometimes we teach them how to do stuff," while ST25 noted that an "Age gap perspective is there but can manage well now." These accounts are particularly relevant to XK because they concern educators' knowledge of learners, digital practices and contextual differences.

4.3 Mixed-method integration

As per figure 2, the quantitative strand showed a clear upward outcome pattern, whereas the qualitative strand explained features of the learning environment surrounding that pattern. The convergence was not interpreted as evidence that 'more technology causes better scores'. Rather, students' accounts point to purposeful alignment, interaction, visual/experience learning and contextual responsiveness as plausible educational mechanisms. The integrated inference is that TPACK-informed lesson redesign may support learning by improving the coherence of the learning environment in which technology is used.

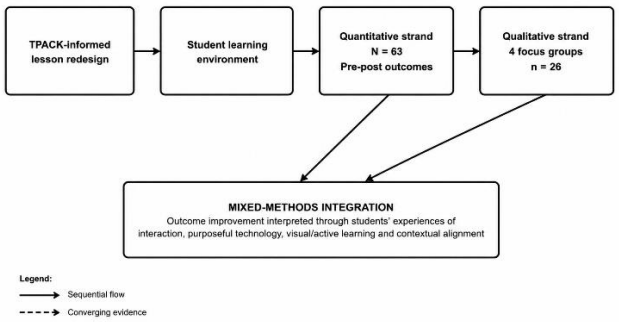

Figure 2. Explanatory integration of quantitative outcomes and student learning environment experiences.

5. Discussion

The principal contribution of this paper is conceptual rather than a second quantitative report on effectiveness. The findings demonstrate how the updated TPACK-in-context model can be applied to nursing education by positioning technology integration within an external educational context and distinguishing that context from educators' knowledge about it. Nursing educators make technology decisions under conditions shaped by infrastructure, curricula, student characteristics, accessibility, clinical relevance and institutional support.

The concise quantitative signal showed substantial improvement in student scores. This pattern is compatible with wider nursing-education evidence showing that well-designed simulation, virtual reality, game-based and other digital approaches can improve learning outcomes (Mulyadi et al., 2021; Woon et al., 2021; Plotzky et al., 2021; Min et al., 2022; Tavares, 2022). However, the qualitative findings caution against attributing benefit to technology alone. Students located value in interaction, visualisation, active participation, alignment and effective use.

This distinction helps interpret the title 'Beyond the PowerPoint Classroom'. The argument is not that presentation software is intrinsically ineffective. Rather, replacing one delivery medium with another without reconsidering pedagogy, content, learner activity and assessment does not necessarily constitute meaningful digital transformation. TPACK offers a framework for redesigning these relationships.

The findings align with recent nurse-educator research. Ait Ali et al. (2023) found that prospective nursing educators reported comparatively greater difficulty integrating technology with pedagogy and content. Pajari et al. (2024) identified evidence-informed guidance, safe and responsible technology use and appropriate learning design as core dimensions of nurse-educator digital competence. Shon et al. (2024) similarly demonstrated the value of faculty development addressing pedagogy, digital resources, teaching strategies, assessment and learner empowerment. Cross-national studies reinforce the need for continuing professional development tailored to educators' competence profiles and contextual needs (Pajari et al., 2025a, 2025b).

The student accounts add another dimension: learners themselves are part of the context. Statements about reciprocal technology support and age-related differences show that technology expertise may not flow only from educator to student. In a TPACK-in-context interpretation, knowing how students access, understand and use technology becomes part of XK. This is particularly important in nursing, where digital fluency must coexist with evidence appraisal, clinical judgement, communication, ethics and human-centred care.

5.1Quantitative Phase: Evaluating Student Outcomes in the Redesigned Environment (Objective 1).

The quantitative evaluation confirms that the redesigned, TPACK-informed learning environment produced significant learning gains across all academic tiers (n=63), including diploma (n=21,33.3%), degree (n=17,27.0%), advanced-certificate (n=15,23.8%), and Master's (n=10,15.9%) programs. Normality assumptions were satisfied for both pre-intervention scores (W=.971, p=.148) and gain scores (W=.970,p=.134), confirming the parametric reliability of the paired-samples t-test comparisons.

These quantitative results provide empirical evidence that students across diverse baseline levels responded positively to the redesigned environment. Rather than benefiting only lower- or higher-level cohorts, the quantitative gains validate that integrating technological tools directly into clinical content and active pedagogy creates a measurably effective learning framework across diploma and postgraduate nursing education alike.

5.2 Qualitative Phase: Student Perceptions of Content, Pedagogy, Technology, and Nursing education Alignment

The qualitative findings provide deeper context for the quantitative gains by illustrating how nursing students experienced the alignment of content, pedagogy, technology, and clinical practice. Students identified that learning was most effective when digital resources were intentionally tied to course objectives and real-world clinical practice rather than introduced as isolated tools. This alignment was realized through visual, experiential strategies—such as using "Bio digital apps" (ST22)—which allowed learners to visualize, discuss, and apply complex clinical concepts.

Participant narratives highlighted that technology added substantial educational value only when embedded in active pedagogy: "I like when teacher integrate technology in class" (ST13) and "Teach using technology effectively" (ST24). These accounts demonstrate that

nursing students perceive technological tools not as independent drivers of learning, but as mechanisms that amplify pedagogical clarity and clinical relevance when seamlessly integrated into instructional design.

5.3 Integration phase: Interpret the combined findings through the lens of the updated TPACK-in-context model, explicitly separating external contextual factors from the educators' Contextual Knowledge (XK).

Integrating the quantitative and qualitative findings through the updated TPACK-in-context framework (Objective 1.2.3) demonstrates that measurable learning gains depend on the dynamic interaction between external environmental conditions and educators' internal Contextual Knowledge (XK). To apply this model accurately, external contextual factors including institutional and technological infrastructure (e.g., 3D anatomy apps and curriculum schedules), learner demographics spanning diverse academic tiers, and high-stakes clinical practice demands must be explicitly decoupled from XK, which reflects the educator's cognitive capacity to interpret and adapt to these variables. The integrated qualitative evidence illustrates that faculty leverage XK to bridge generational gaps, acknowledging that while an "age gap perspective is there," instructional strategies allow them to "manage well now" (ST25). Furthermore, strong XK enables educators to reconfigure traditional classroom hierarchies by drawing on student digital fluencies ("sometimes we teach them how to do stuff" [ST26]) and selecting context-responsive tools matched to physical spaces and clinical constraints. Ultimately, while external factors establish the structural boundaries of the redesigned learning environment, it is the educator's Contextual Knowledge that determines how effectively TPACK decisions are operationalized to optimize student learning outcomes.

6. Conclusion and Recommendations

The updated TPACK-in-context model provides a useful lens for understanding technology integration as nursing learning-environment design. A substantial improvement in student scores was accompanied by qualitative accounts emphasizing alignment, active and visual learning, purposeful technology integration, interaction and contextual responsiveness. Distinguishing external context from Contextual Knowledge clarifies why effective digital teaching requires more than technological skill: educators must understand the learners, resources, constraints and clinical expectations within which technology, pedagogy and nursing content are combined. The resulting conceptual application positions TPACK-informed teaching as context-responsive redesign of the nursing learning environment.

The limitation of this study is that student outcome components used a pre/post design without a parallel student control group, so improvement cannot be attributed exclusively to TPACK-informed teaching. The study was conducted in the Maldivian nursing-education context, and transferability should consider differences in infrastructure, curricula and institutional conditions. The qualitative findings represent participating students' experiences. Generation Alpha was not sampled; its discussion is prospective only therefore it is recommended to improve research findings using a pre/post design without a parallel student control group for stronger methodological approach. As the first Gen Alpha generation of students would be entering higher education in 2028, future studies need to determine the educational technological pedagogies which can be embedded into their learning needs.

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Paper Contribution to Related Field of Study

This paper contributes to nursing education scholarship by extending the updated TPACK-in-context model (Petko et al., 2025) into a discipline-specific application. It conceptualises the nursing learning environment as an academic environment–behaviour system in which external context and educators' Contextual Knowledge (XK) jointly shape technology-integrated teaching. Building on this application, the paper proposes TPACK-N (a Framework focus for the Nursing Discipline), offering nurse educators, curriculum designers and faculty developers a discipline-relevant lens for aligning nursing content, pedagogy, technology, learner needs and clinical context. The findings inform faculty development priorities and learning-environment evaluation practices for technology-enhanced nursing education, and provide an empirical, context-responsive counterpoint to research that attributes learning gains to technology adoption alone.

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