Doctoral Dissertation

Building Language Instructors' Technological Pedagogical Content Knowledge (TPACK) in Transnational Higher Education Context

by

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Abstract

The dissertation focuses on building instructors' Technological Pedagogical Content Knowledge (TPACK) in the context of Transnational Higher Education (TNHE) during the COVID-19 pandemic. It emphasizes the importance of integrating technology, pedagogy, and content knowledge for effective teaching and learning, particularly in language instruction within TNHE. The study aims to identify opportunities that support language instructors' development in TPACK, as well as the development of individual knowledge domains like Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK).

The dissertation comprises seven chapters, including a literature review on TPACK and TNHE during COVID-19, and an outline of the research methodology, which combines qualitative and quantitative approaches. It includes two main studies: the first quantitatively assesses changes in TPACK over three semesters using a validated survey tool, while the second is a longitudinal case study that provides deeper insights into the opportunity to learn behind these changes.

Study 1 involves language instructors from Chinese TNHE institutions. It uses Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) to examine the TPACK survey instrument and employs Repeated Measures ANOVA to determine changes in TK, CK, PK, and TPACK across semesters.

Study 2, a longitudinal case study, investigates the development of TPACK and its sub-domains in various contexts during COVID-19 from Opportunity to Learn (OLT) perspective. It focuses on the practices of three instructors in TNHE institutions to understand how their TPACK develops amidst the pandemic challenges. The data sources came from language instructors' teaching practices, interviews and CPD programs during COVID-19. Textual data content analysis is used

to explore language instructors' TPACK and its occurrence rate, and thematic analysis is used for coding OTL for TPACK development in CPD programs, teaching practices and university context. The results provide a cyclical interaction between opportunities supporting CK, PK, TK and TPACK, and well-rounded teacher concept is proposed in TNHE language education context. It also suggests that engaging in opportunities supporting TPACK could highlight limitations in teachers' TK, CK, PK, encouraging them to seek further learning in teaching.

Overall, the dissertation provides empirical evidence on TPACK development, going beyond self-reported data, contributing to the understanding of TPACK development in TNHE language instruction, informing policy and curriculum decisions, and enhancing teaching and learning outcomes in diverse contexts.

Key words: TPACK, transnational higher education, knowledge development, COVID-19, opportunity to learn

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

1. Introduction

1.1 Problem statement

Being technologically savvy is a skill that is quickly becoming highly markable in the educational world (Chapelle & Sauro, 2020; Tamim et al., 2011). Technological advancements have significantly impacted the landscape of education. In higher education, the fusion of technology, pedagogy, and content knowledge is pivotal for effective teaching and learning (Farjon et al., 2019; Khlaif & Salha, 2022). Technological pedagogical content knowledge (TPACK) is a framework that emphasizes the integration of technological, pedagogical, and content knowledge for effective teaching and learning (Mishra & Koehler, 2006; Graham, 2011). This framework offers a comprehensive lens through which educators can navigate the integration of technology in educational settings (Koehler & Mishra, 2008; Niess, 2005, Chai et al., 2011; Harris& Hofer, 2011; Yeh, 2013; Roussinos & Jimoyiannis, 2019; Haley-Mize & Bishop, 2014).

The traditional technocentric model often emphasizes the integration of technology into education without necessarily considering the broader context or pedagogical strategies experience (Jaipal-Jamani & Figg, 2014). However, more effective approaches involve decontextualized learning, where technology is used to facilitate a deeper understanding of the content while also considering the context in which the teaching occurs (Graham et al., 2012; Webb, 2011; Zahn et al., 2012). For example, educational institutions integrated technology to deliver courses online, providing access to lectures, course materials, assignments, and assessments through learning management systems (LMS) and other online platforms during COVID-19 (Raza et al., 2020). Educators have received training and professional development to effectively utilize and integrate these technologies into their teaching practices during this hard period (Kidd & Murray, 2020; Quezada et al., 2020). This technology-integrated teaching approach acknowledges that leveraging

technology in a way that aligns with effective teaching strategies and the specific needs of the learners (Aduba & Mayowa-Adebara, 2021). Thus, the challenge lies in understanding how to effectively develop and empower among transnational higher education (TNHE) instructors with the nuanced understanding and application of TPACK, ensuring meaningful technology integration that aligns with both pedagogical principles and the unique needs of transnational learners.

Nonetheless, although numerous studies in the past few years have increasingly focused on how TPACK develops or changes adopting to this challenging period (DeCoito & Estaiteyeh, 2022; Khar Thoe Ng, 2022), few researchers have conducted systematic investigations to underly learning opportunities that contribute to the perceived TPACK improvement TNHE language instructors (Manokore & Kuntz, 2022; Rochsantiningsih & Aniq, 2023). Specifically, previous studies have focused on TPACK assessment instrument development outlined in distinct domain (Angeli & Valanides, 2009), yet in a scant and fragmented manner. Thus, few explorations have been either systematically combined or given appropriate weight for evaluating explore factors contributing to technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CT) and TPACK development from the perspective of language teaching in TNHE (Adipat, 2021; Chai et al., 2013). Also, there was limited specific research on qualitative exploration tailored to transnational contexts that facilitate the development of TPACK for language instructors (Hsu, 2016). These studies should consider the diverse backgrounds and contexts that transnational instructors work in (Baser et al., 2015; Dalal et al., 2017). And the majority of results published are from self-reported data, often gathered through surveys, questionnaires, or interviews, recalling past experiences or behaviors may lead to recall bias (Kılıçkaya, 2009). Therefore, the findings from these studies cannot be universally applied to TNHE contexts due to either methodological

restrictions or limitations specific to the context. By addressing these research gaps, understanding of TPACK development for transnational language instructors could be enhanced, which in turn can lead to more effective language teaching for teachers and improved learning outcomes for students in diverse language learning contexts.

1.2 Research scope

Language instructors' TPACK building in TNHE context is chosen as the research scope for this dissertation study because even before the outbreak of the COVID-19, rapid revolution in educational technology has already advanced understanding of TPACK, its application in language education, and its implications for diverse educational contexts (Koh et al., 2014). It investigates the critical domain of TPACK development among TNHE language instructors, examining the capacity building opportunities of technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) and TPACK in the pursuit of enhancing teaching efficacy within diverse educational settings. Also, the global pandemic required language instructors to be proficient in leveraging the latest tools and methodologies, adapting to the challenging educational landscape (Moorhouse & Kohnke, 2021). Understanding the complexities, challenges, and best practices of integrating TPACK within the TNHE context is essential to equip educators with the tools necessary to foster engaging and effective teaching experiences.

Extensive research has explored by researchers on how teachers improve their knowledge at the intersection of technology, teaching methods, and subject matter, known as TPACK. In most cases, investigations have occurred within the realm of pre- teacher training, focusing on integrating technology as a primary method for enhancing TPACK (Aldemir Engin et al., 2022; Kay, 2006; Tokmak et al., 2012). Additionally, specific training programs for language teachers aim to cultivate their ability to integrate technology into their instructional practice. These

programs often feature activities like cooperative development of teaching resources, engaging discussions, reflective practices, selecting relevant technological tools, organizing curriculum, preparing for classes, and updating evaluation measures (Harvey & Caro, 2016). It's widely recognized in discussions that mastering the interplay of technology, teaching, and content is crucial for teachers to elevate their instructional efficacy and consequently achieve learning outcomes of their students (Lee & Kim, 2014). It should be noted that opportunity to learn (OLT) of TPACK capacity building has remained unclear in TNHE (Major et al., 2021). In the field of language instructors, who account for large amount of TNHE teaching faculty, they may have limited online pedagogical knowledge, skills, and confidence for delivering virtual lessons when facing big challenges (Wang, 2022). As technology continues to develop and shape the TNHE landscape, especially after the outbreak of COVID-19, investigating TPACK in TNHE context becomes important to improve teaching practices and ultimately maintain the quality of education in an increasingly globalized world.

Therefore, this research endeavors to shed light on OTL involved in cultivating TPACK among TNHE language instructors, contributing to a richer understanding of technology integration within the realm of TNHE. It also focuses on tracing language instructors' TPACK development by validated instrument and analyzing how they develop TPACK overtime during COVID-19. Thus, the research scope focuses on a specific period (COVID-19) and specific domain (language teaching).

1.3 Significance of the study

Seeking out learning opportunities to build instructors' TPACK or develop their TPACK means to effectively integrate TPACK which leads to higher quality language instruction, fostering improved student engagement, understanding, and academic performance, thereby enhancing the

overall quality of education in TNHE. This is particularly relevant given the rapid shift to online and remote teaching methods necessitated by the COVID-19 pandemic, which likely impacted instructors' use of technology in their teaching.

By identifying learning opportunities to build TPACK and providing recommendations for professional development that equip language instructors with the necessary skills to navigate and excel in this educational landscape, language instructors can tailor teaching strategies, ensuring inclusivity and effective education delivery to a multicultural audience. They can enhance optimize technological integration and promote effective educational outcomes in transnational higher education settings as well.

This dissertation can also offer practical guidelines for teacher educators and TNHE institutions. By exploration on OTL of TPACK building, the research on TNHE language instructors' TPACK can also provide insights to inform the design and implementation of targeted professional development programs. These programs can better equip language instructors, aligning their skills with the demands of modern education and technology. And institutions that invest in building TPACK among their language instructors can gain a competitive advantage by offering high-quality, technologically enriched language programs, attracting more students and enhancing institutional reputation.

In summary, to mend the current literature gaps, this research combines both quantitative and qualitative approaches in TPACK assessment instrument validation and learning opportunities of TPACK building exploration among language instructors in TNHE context. It will influence teaching methodologies, student learning experiences, and the overall quality of language education in TNHE, ultimately contributing to the advancement of TNHE educational landscape.

1.4 Research objectives

The overarching purpose of this research (MRO) is to build instructors' TPACK in the context of TNHE through identifying the opportunities that support language instructors' TPACK development. Accordingly, this study investigated twofold objectives: the first sub-objective (SRO1) is to explore and understand the changes and developments in TPACK of language instructors during the specific timeframe of the COVID-19 pandemic; the second sub-objective (SRO2) is to analyze how instructors develop TK, PK, CK and TPACK from OTL perspective.

SRO1 aims to determine how the TPACK of language instructors changed during the pandemic. It looks at the "what" — what were the specific development in their teaching knowledge during this period. SRO2 aims to understand "how" these changes came about by examining the learning opportunities that instructors had. Essentially, while SRO1 identifies the changes, SRO2 seeks to understand the mechanisms through which development were facilitated. Findings from SRO1 can provide a baseline against which the findings from SRO2 can be evaluated. While achieving SRO2 needs to have an invalidation of assessment instrument and evaluate the development of TPACK from SRO1, thus exploring the learning opportunities to build TPACK. SRO1 provides the observable data on the changes in TPACK, and SRO2 contextualizes these changes by highlighting the learning opportunities that might have contributed to them. Also, Study1 is about knowledge for teaching (from self-assessment data), and Study2 is about knowledge in teaching (mainly from observation and documents). Though knowledge in teaching and knowledge for teaching are both important, knowing the pedagogical knowledge does not mean having the ability to apply this knowledge effectively in teaching practice. It acknowledges that expertise in teaching requires a blend of theoretical understanding and practical experience. While SRO1 investigates the foundation of a teacher's expertise, and SRO2 explores the practical application of this knowledge

in real classroom settings. Both sub-objectives, when studied together, give a holistic picture of the knowledge evolution of TPACK among language instructors during the COVID-19 pandemic. In essence, achieving these two sub-objectives will fulfill the MRO. Figure 1 demonstrates how the MRO is achieved through the two sub-objectives.

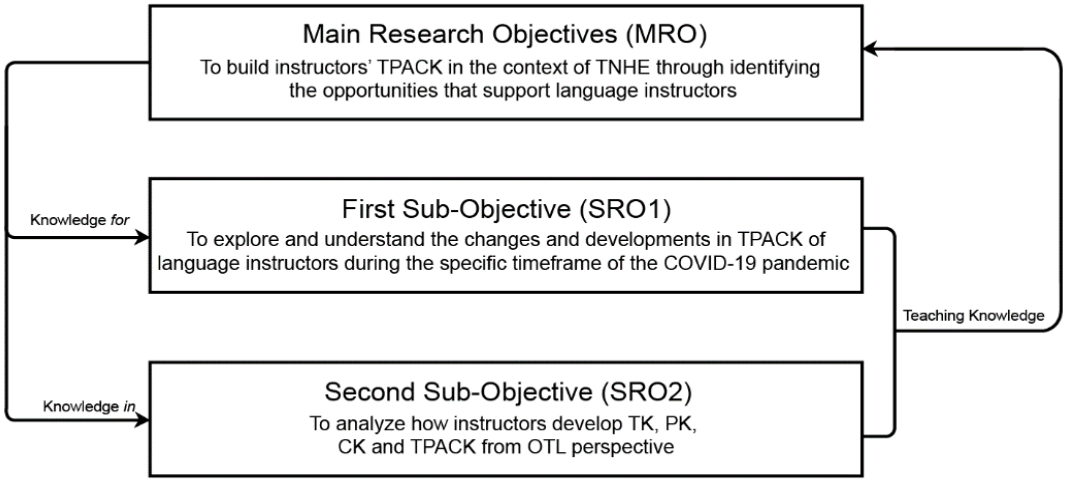

Figure 1 Research map

The research scope involves the creation and validation of a specialized instrument for assessing TK, PK, CK and TPACK knowledge domains within the context of transnational language instruction, a longitudinal study to track the development of TK, PK, CK, and TPACK over time and analysis of learning opportunities and experiences further enhance these knowledge domains.

1.5 Structure of the dissertation

This dissertation is comprised of the following seven chapters:

Chapter 1 (Introduction) provides an overview of the research, the background of the research problem, the research objectives, and the significance of the study.

Chapter 2 (Literature Review) describes the contextual framework of the study and critically reviews the literature relating to TPACK and transnational higher education during COVID-19. This chapter also provides the theoretical background for opportunities that language teachers developing TPACK.

Chapter 3 (Research Methodology) outlines a comprehensive approach that leverages the strengths of both qualitative and quantitative research. It includes how these qualitative and quantitative methods are combined effectively in the study, providing detailed information on the procedures followed from the inception of the research idea to the final analysis and interpretation of data.

The development trace phase (Study 1) includes instrument validation and a quantitative longitudinal study to evaluate the changes of TK, PK, CK, and TPACK over time. By conceptualizing the measurement instrument, defining relevant constructs, and crafting appropriate items to represent TK, PK, CK and TPACK components tailored to the transnational higher education language instruction context, Study 1 first focuses on ensuring an adapted instrument aligns with the specific needs and challenges faced by language instructors in this educational domain. Next, Study 1 is designed to capture the dynamic evolution of instructors' competencies in TK, CK, PK and TPACK in the timeframe of significant educational disruption and transformation--- COVID-19.

The opportunity exploration phase (Study 2) includes longitudinal case analysis on OTL, such as continuous professional development, teaching practice and university contexts, which further enhance these knowledge domains for TNHE language instructors.

Chapter 4 (Quantitative analysis of TPACK knowledge changes in TNHE language instructors during COVID-19) is to quantify the development in each TPACK domain

(TK, PK, CK, and TPACK) among the language instructors. The study uses an adapted version of a survey tool (Schmidt, 2009) to assess various dimensions of TPACK, which indicates instructors' knowledge *for* teaching. It then employs a paired ANOVA (Analysis of Variance) test across three consecutive semesters to compare the means of the same group at different times and is suitable for measuring changes or growth in a variable over time.

Chapter 5 (Case investigation on TNHE language instructors' TPACK development within the context of OTL) presents a detailed, longitudinal case examination of how language instructors developed their TPACK competencies over the course of the COVID-19 pandemic, which indicates knowledge *in* teaching. Through in-depth case studies spanning three semesters, the research aims to uncover OTL and their influence on this development, offering rich insights into the intersection of technology, pedagogy, and content knowledge in a time of unprecedented educational challenges.

Chapter 6 (Discussion and Conclusion) synthesize the findings to draw comprehensive conclusions about the role of OTL (continuous professional development programs, teaching practices, and university contexts) in the development of TK, PK, CK, and TPACK among transnational language instructors, highlighting key factors that significantly contribute to knowledge growth. Based on the research findings, it proposes policy recommendations to enhance learning opportunities that foster the development of TK, PK, CK, and TPACK among transnational language instructors. Also, this dual focus on teachers' knowledge for teaching and its use in their teaching practice provides a more complete picture of teacher competence, highlighting areas of strength and potential areas for development in their professional practice.

Chapter 7 (Contribution to Knowledge Science) has the potential to advance knowledge science by providing a deeper understanding of TPACK development in transnational language instruction, informing policy and curriculum decisions, and contributing to the refinement of educational methodologies and practices to enhance teaching and learning outcomes in diverse contexts. Thus, this dissertation makes contributions to the field of educational technology, pedagogy, and language instruction.

2. Literature Review

2.1 Transnational higher education during COVID-19

Teaching in transnational education is complex and multifaceted, involving diversity in people, cultures, roles, contents, programmes and modes of delivery. The swift increase in transnational programmes has underscored the importance of professional development in ensuring quality education.

The COVID-19 pandemic has had an unprecedented impact on the landscape of TNHE from the physical mobility of scholars and students, which is the most frequent cross-borders mode of knowledge transfer in higher education (Teichler, 2004). Owing to public health concerns (Weaver, 2022), the COVID-19 pandemic acted as a natural breaching experiment, whereby normal pedagogies were suddenly disturbed, and the teaching faculty needed to adjust their instruction. Educational institutions and their teachers, professors, and students are quickly moving from physical classrooms to online settings because of the global COVID-19 pandemic (Lin & Johnson, 2021). The impediments to successful transitions reflect the positive experiences of educational change during COVID-19. The policy differences between national systems during the COVID-19 pandemic are also a barrier to academic synergies from international collaborations (Lee& Soon-Jeong, 2022). This is because there is a risk that a partnership university could interpret such differences as an indication of reluctance to engage in exchange, cooperation and mobility (Cretu& Hu, 2023). Online learning platforms, remote laboratory simulations and online proctoring are repair strategies used for breaching normal classroom norms during COVID-19 (Vahle et al., 2023). Many TNHE institutions have developed or adopted online learning platforms that allow the teaching faculty to prepare course materials and conduct virtual classes from anywhere in the world (Akın et al., 2022). These platforms often include features such as live video

conferencing, discussion forums and interactive quizzes to help students engage with the course content.

The pandemic has driven educational institutions to carefully balance the use of information technology and TNHE quality assurance. Therefore, the COVID-19 pandemic acted as a catalyst for teachers to develop their technological pedagogical knowledge, pushing them to integrate technology, pedagogy, and content knowledge in new and often challenging ways.

2.2 TPACK instrument (for *SRO1*)

2.2.1 General TPACK studies

When Mishra and Koehler (2006) introduced the TPACK framework, it rapidly gained significant influence in the fields of education and educational technology. This framework became a crucial tool for educators and researchers to understand and implement technology integration in teaching more effectively. The TPACK framework, by including TPACK as its own component, underscores the complex and integrated nature of knowledge needed for effective technology integration in teaching. It emphasizes the importance of not just possessing knowledge in technology, pedagogy, and content separately but understanding how to weave these strands together to enhance educational practice and student learning (Mishra& Koehler, 2006).

Prior to TPACK, the process of integrating technology into education lacked a solid theoretical foundation. Educators were attempting to use new technologies in their teaching, but without the guidance of a robust theoretical model, this integration was likely ad hoc and potentially less effective (Rets et al., 2020).

The TPACK framework extends the concept of Pedagogical Content Knowledge (PCK) by adding a third critical component: technological knowledge (TK). Shulman (1987) posited that for effective teaching, teachers must possess a deep understanding of both the content they're teaching

and the pedagogy appropriate for conveying this content. He introduced PCK (as illustrated in Figure 2) as a distinctive domain of knowledge that fuses pedagogy and content, positioning it as essential for educators. Building on Shulman's foundation, Angeli and Valanides (2005) introduced a dimension of information and communication technologies (ICT) to the framework, thereby giving rise to ICT-related PCK. This expanded conceptualization enriched Shulman's original PCK by incorporating the pivotal role of ICT in modern education. Angeli and Valanides (2005) portrayed ICT-related PCK as a specialized domain of knowledge, crafted from the interplay of five core components: content knowledge, pedagogical knowledge, knowledge of learners, ICT proficiency, and contextual understanding.

After Mishra and Koehler introduced their framework in 2006, they built upon Lee Shulman's initial conception of two fundamental knowledge bases essential for teaching: content knowledge (CK) and pedagogical knowledge (PK). Mishra and Koehler expanded this model by integrating a third crucial component, technological knowledge (TK), thus forming the Technological Pedagogical Content Knowledge (TPACK) framework. By integrating these three knowledge bases, the TPACK framework suggests that effective teaching requires more than just understanding content and pedagogy; it also requires understanding how to integrate technology into the curriculum to enhance learning. It's about finding the intersections between all three knowledge domains and understanding how they can complement each other to create effective, engaging, and meaningful learning experiences. The TPACK framework has become a fundamental model in understanding and developing teacher competencies for the digital age, emphasizing that teachers need to be well-prepared to integrate technology into their teaching practices in ways that enhance learning outcomes. The addition of these four domains to the TPACK framework highlighted the complexity of teaching in the digital age. It's not enough to

just know about technology, content, or pedagogy in isolation; effective educators must understand the intricate ways these components interact and influence each other in the context of teaching and learning. This comprehensive approach is what enables teachers to effectively integrate technology in their classrooms to enhance educational outcomes. As shown in Figure 3, Koehler and Mishra (2008) conceptualized the TPACK framework in terms of seven knowledge domains, namely, (a) Technological Knowledge (TK), (b) Pedagogical Knowledge (PK), (c) Content Knowledge (CK), (d) Pedagogical Content Knowledge (PCK)—the interaction of PK and CK, (e) Technological Pedagogical Knowledge (TPK) – the interaction of TK and PK, and (g) Technological Content Knowledge (TCK)—the interaction of TK and CK, and Technological Pedagogical Content Knowledge (TPACK)—the interaction of PCK, TCK and TPK (see Figure 3).

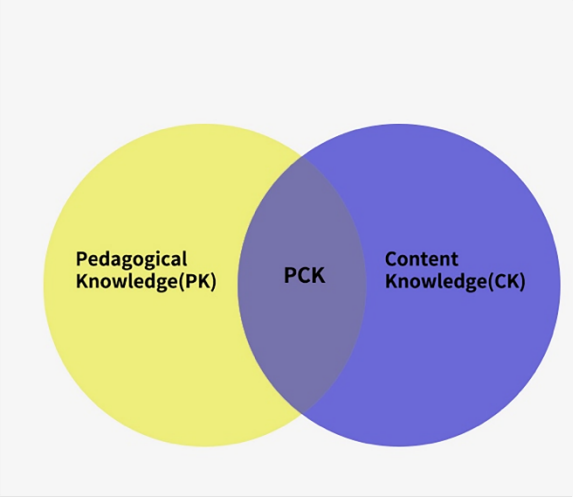

Figure 2 PCK model

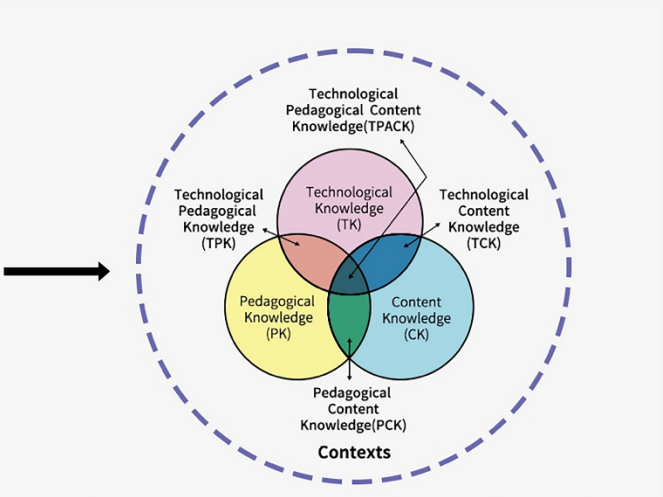

Figure 3 TPACK model

The TPACK framework is frequently visualized using a Venn diagram that consists of three overlapping circles, with each circle representing a different form of teacher knowledge: CK, PK, and TK. This visual representation highlights the interconnectedness of these forms of knowledge and how they combine to form what is known as TPACK. The TPACK framework has been instrumental in helping teachers to think both critically and creatively about how they develop and deliver educational content (Yildiz Durak, 2019). By incorporating this framework, teachers are encouraged to not only understand their subject matter but also to consider how the use of technology can enhance the learning experience. The TPACK framework has gained widespread acceptance among educational researchers and practitioners. This popularity is due to its practical applicability and its relevance in contemporary education, where technology plays a significant role. By adopting the TPACK framework, educators are better equipped to design and implement teaching strategies that effectively incorporate technology, leading to enhanced learning outcomes. This approach recognizes that the thoughtful and purposeful integration of technology in education can significantly improve the quality of teaching and learning (McGrath et al., 2011).

In studies attempting to explore and validate the TPACK framework, some researchers have faced difficulties in clearly identifying and measuring all seven of these knowledge domains (Archambault& Barnett, 2010; Chai et al., 2011; Koh et al., 2010; Zelkowski et al., 2013). This could be due to the complex and overlapping nature of these domains, making it challenging to distinctly separate and assess each one, which means this theoretical framework deserves more systematic and robust research investigation in domain-specific knowledge. Therefore, this study focuses on impacts of three separate domains in TPACK development and invalidation in TNHE context where an instructor teaches foreign languages, namely technology knowledge (TK),

pedagogy knowledge (PK) and content knowledge (CK). These three domains of TPACK framework are explained as followed in the context of TNHE language teaching:

Technological knowledge (TK) refers to an educator's understanding of the specific technologies and tools available, their features, functionalities, and appropriate applications within educational settings (Pop, 2010). TK in language teaching refers to instructors' understanding and proficiency in using various technologies to enhance the teaching and learning of languages. It involves familiarity with technological tools, applications, software, hardware, and online platforms that can support language instruction and promote language acquisition. Zejda et al. (2020) explored how a collaborative effort among seven institutions to integrate videoconferencing and virtual reality technologies could enhance English language learning for adults. A reflection on the experiences of implementing a virtual classroom to address global competencies in the areas of knowledge, empathy, acceptance, foreign language ability, and intercultural teamwork was also investigated (Patterson et al., 2011). In this research, technological knowledge related to COVID-19 includes how universities, colleges, and educational institutions have adapted to the challenges posed by the pandemic through the integration of technology. Thus, TK does is not only about online learning platforms and tools, but also about instructors' relationship with technology. It involves rethinking pedagogy, assessment, and the overall instructors' capacities to ensure that education continues to be effective, engaging, and accessible in the face of ongoing challenges (Gopika& Rekha, 2023).

Pedagogical knowledge (PK) focuses on the principles and practices of teaching and learning, encompassing instructional strategies, assessment techniques, classroom management, and understanding the diverse needs and abilities of learners (Bunch, 2013). PK in TNHE language teaching refers to educators' expertise in employing effective teaching strategies, methods, and

approaches specific to the context of teaching languages in a transnational or cross-border educational setting (Ollerhead, 2016). Gatbonton (2008) examined the categories of pedagogical knowledge of novice ESL teachers as gleaned from their verbal reports of what they were thinking about while teaching.

Content knowledge (CK) pertains to an educator's deep understanding of the subject matter they are teaching (Banegas, 2021). In the realm of TNHE language instruction, the term refers to the instructors' comprehensive grasp of the subject they teach, namely language and linguistics, within the framework of education that spans across national borders. Kissau & Algozzine (2017) conducted a study to investigate into what specific content knowledge is vital for those teaching foreign languages effectively. They employed a mixed-methods approach, which means they combined both quantitative and qualitative research techniques to gather comprehensive data. In Ball's (2010) research, it delineated four distinct categories of content knowledge, each deemed critical for effective teaching. These categories comprehensively explored the understanding that educators need to possess in their subject area to teach effectively. From this research, CK is crucial for ensuring the language teaching syllabus is robust, pertinent, and harmonized with the educational objectives of the originating and receiving nations.

2.2.2 Development and validation of instrument assessing TPACK

The demand to evaluate the effectiveness of technology integration policies, curricula, and related training programs has led to the creation of various tools to measure teachers' TPACK. Notably, one of the earliest and most referenced tools is the self-assessment instrument developed by Schmidt et. al (2009) for pre-service elementary teachers (PK-6). Originating from pre-existing assessments for technology utilization in education, Schmidt et al. validated this tool through a comprehensive analysis involving expert reviews and factor analysis, utilizing a sample of

instructional technology students. The development and validation of an instrument assessing TPACK involves a multidimensional and iterative process.

Specialized tools have also been formulated to evaluate TPACK in the context of language education. The initial tool of this kind was introduced by Schmidt et al. (2009) which confirmed TK, CK, PK, PCK, TCK, TPK, and TPACK seven domains. Then Ching et al. (2010) confirmed TK, CK, PK and TPACK domains. Chai et al. (2013) used self-assessment method to tailor specifically for assessing TPACK among science teachers in Singapore, it modified the generic content-related components and designed for pre-service teachers, to fit the unique needs of science instruction. In an effort to assess the TPACK, Zelkowski et al. (2013) four factor structure in TPACK assessing. Baser et al. (2016) took a different approach by constructing a completely new tool known as TPACK-EFL, dedicated to measuring technological pedagogical content knowledge in the context of teaching English as a foreign language. And the validating of items effectively captured the seven aspects of TPACK. All studies mentioned were successful in identifying four domains of TPACK—TK, PK, CK and TPACK. This confirms the multidimensional nature of TPACK. All the instruments aim to assess how technology is integrated into teaching, but they do so with different emphases and theoretical indications. These differences reflect the diverse ways TPACK can be conceptualized and utilized in educational contexts.

Based on the above chronological review of instrument validation, it can be concluded that there has been minimal quantitative research specifically aimed at measuring TPACK in the context of language instruction within TNHE settings. This suggests a need for more empirical, data-driven studies in this particular area. By conducting studies that specifically target the nuances of TPACK in language teaching within TNHE, educators and researchers could gain a clearer

understanding of how TPACK develops in this context. This could lead to better-informed strategies for teacher training and technology integration in language education. More refined and targeted quantitative research on TPACK in the specific context of language teaching within TNHE institutions would not only contribute to the academic understanding of TPACK but also potentially improve practical approaches to teacher training and technology use in language education.

2.2.3 Correlations within the TPACK framework

The TPACK framework offers a comprehensive lens through which to investigate the interplay between a teacher's technological, pedagogical, and content knowledge (Koehler & Mishra, 2008). The concept of correlation within this framework has been the subject of empirical studies aiming to understand how these knowledge domains influence one another and collectively contribute to effective teaching practices with technology.

Academic inquiries into the correlations within the TPACK framework often seek to quantify the degree to which the development in one area of knowledge impacts another. For example, Archambault and Barnett (2010) found significant correlations between teachers' self-reported pedagogical knowledge (PK) and their technological pedagogical knowledge (TPK), suggesting that a teacher's general pedagogical skills are related to their ability to integrate technology into teaching.

Empirical studies, such as those by Schmidt et al. (2009), have utilized statistical methods like Pearson's correlation coefficients to examine the relationships between TPACK constructs. Their research revealed that strong TK does not necessarily predict strong TPACK, emphasizing that the integration of content, pedagogy, and technology is more complex than the sum of its parts.

Graham (2011) extended this line of inquiry by examining how professional development affects the TPACK framework components. The study suggested that enhancements in technological knowledge (TK) are not always directly correlated with improvements in TPACK, indicating that professional development needs to be holistic and contextual to bridge the knowledge domains effectively.

Cox and Graham (2009) conducted a meta-analytic review that synthesized findings from multiple studies, providing evidence of varying degrees of correlation between the TPACK domains across different educational contexts. This body of work underscores the importance of considering contextual factors when interpreting correlations within the TPACK framework.

In a longitudinal perspective, Voogt et al. (2013) considered how TPACK develops over time, finding that correlations between TPACK domains can evolve as teachers gain more experience with technology integration. This suggests that the relationship between domains is dynamic, rather than static.

Research by Chai et al. (2013) investigated into how cultural contexts influence the correlation between TPACK components, highlighting that the strength and nature of these correlations can vary based on educational settings and cultural expectations.

Although Although TPACK framework theoretically posits interconnections between seven knowledge areas (like how TK intersects with PK to form TPK), empirical studies have struggled to reliably and consistently find clear, measurable relationships among these domains. (Scherer et al., 2017). Due to the overlapping nature of these domains (for example, TPACK as a combination of TPK, TCK, and PCK), it is also challenging to separate and measure each domain independently in research studies (Lachner et al., 2021). This indicates a need for ongoing research to further

refine and validate the framework. Such insights are essential for structuring teacher education and professional development programs to optimize technology integration in educational settings.

2.2.4 Development of language instructors' TPACK

The move from English as a Foreign Language (EFL) to academic English as both a discipline and a mode of delivery in TNHE institutions reflects a significant shift in language instruction. This shift acknowledges the role of English not just as a subject to be learned, but as a critical tool for academic engagement across disciplines. The division of academic English into oral (speaking and listening) and written (writing and reading) competencies caters to the comprehensive language needs of students in a global academic environment. Co-teaching practices, especially between Chinese and international staff in TNHE institutions, enrich the academic experience by bringing diverse linguistic and cultural perspectives into the classroom. This method enhances the curriculum with international insights and practices, fostering a more inclusive and globally aware educational environment. Such an approach not only aids in language acquisition but also prepares students for the increasingly interconnected world where cultural competence and communication.

To have an updated understanding and robust research results of TPACK in language teaching studies, the study utilized the Web of Science (WOS) database for literature search. It employed a specific search strategy using two key terms or phrases to filter and find relevant articles within the WOS database, which were "TPACK" and "language teaching". After eliminating duplicated as well as papers that were indexed in SSCI, SCI or AHCI, 55 publications were left for detailed examination. The 55 publications were organized into four areas:

The first area is exploring TPACK (n=17). This area involves research aimed at understanding various facets of TPACK. It is about probing the depth, relationships, and dynamics of TPACK in teaching contexts. The second area is assessing TPACK (n=6), which is dedicated

to the development and validation of instruments that measure TPACK. It's about creating reliable and valid tools that can assess the extent and nature of teachers' TPACK. The third area is developing TPACK (n=10). Research in this area focuses on interventions designed to enhance teachers' TPACK. This could include professional development programs, training workshops, or classroom-based strategies aimed at improving teachers' ability to integrate technology with pedagogy and content effectively. The final area is applying TPACK (n=12), which involves applying the TPACK framework to the practical design and implementation of technology-enhanced learning environments and platforms. This research takes the theoretical framework of TPACK and using it to inform the development of real-world educational technologies and strategies.

The critical review of research on TPACK in language teaching has shown that teachers may express confidence in their TPACK abilities, yet often use technology in traditional, teacher-centered ways (Yang, 2022). While studies have assessed TPACK by clearly defining its seven sub-domains through content-specific strategies and technologies in survey items (Wang, 2022), the majority of research has focused on understanding language teachers perceived TPACK knowledge base and how interventions affect its development (Habibi et al., 2019; Liu et al., 2019; Yang, 2022). However, there appears to be a shortage of longitudinal research tracking the development of TPACK over time, providing insights into how language instructors evolve in their use of technology in educational settings. Except that, there is a notable gap in research examining TPACK in actual classroom practice. Most existing studies rely on self-reported data rather than observational data. Thus, there's a call for future research to focus on practical classroom applications of TPACK and to understand how TPACK development occurs in other environments such as transnational education with different educational standards and technology access.

From the above analysis, earlier research often treated TPACK as universally applicable, not sufficiently accounting for variations in context focus, integration challenges and rapid technological development. However, language instruction in TNHE is rather different from the traditional mode. The move from English as a Foreign Language (EFL) to academic English as both a discipline and a mode of delivery in TNHE institutions reflects a significant shift in language instruction. This shift acknowledges the role of English not just as a subject to be learned, but as a critical tool for academic engagement across disciplines. The division of academic English into oral (speaking and listening) and written (writing and reading) competencies caters to the comprehensive language needs of students in a global academic environment.

Co-teaching practices, especially between Chinese and international staff in TNHE institutions, enrich the academic experience by bringing diverse linguistic and cultural perspectives into the classroom. This method enhances the curriculum with international insights and practices, fostering a more inclusive and globally aware educational environment. Such an approach not only aids in language acquisition but also prepares students for the increasingly interconnected world where cultural competence and communication skills are essential.

Thus, applying TPACK in TNHE classroom settings has posed challenges with the above two characteristics in language teaching in TNHE institutions during COVID-19. For example, teachers might not have enough training or support to integrate technology with pedagogy and content knowledge effectively, leading to underutilization or superficial use of technology in academic language instruction. Also, rapid technological changes raise new research topics for co-teaching. The fast pace of technological advancement means that the TPACK framework needs continual updates and revisions to stay relevant, which has been a struggle for research to keep up with. These issues have led to calls for more nuanced, contextually sensitive, and dynamic

approaches to understanding and improving the integration of technology in language teaching through the TPACK framework.

2.3 Opportunities that support teachers' knowledge building (for SRO2)

Teaching learning are embedded and dispersed throughout various professional settings, such as teacher training programs and the school environment itself (Han & Patterson, 2020). It is crucial for the opportunities that enable teaching proficiency to be widespread among diverse resources. Such resources encompass academic coursework, observational learning in classrooms, and actual teaching practice, among others.

Opportunities to Learn (OTL) as conceptualized by Carroll (1989), refers to the circumstances or environments that give individuals or learners a fair and sufficient chance to acquire new knowledge, skills, or competencies. It is a fundamental construct in educational psychology and instructional design, focusing on the conditions necessary for effective learning (Ottmar, 2019).

Carroll's (1989) work emphasized the concept of "time" as a critical factor in the learning process, yet neglected, opportunity in education highlights the importance of considering both the amount and effective use of time in facilitating learning. In other words, learning depends not only on the time allocated for it but also on the time required by a student to learn the material. The opportunity in the teacher professional trainings provide in-service teachers time to develop their understanding of TPACK. In the context of teaching and technological knowledge building, OTL refers to the specific instances and conditions that enable educators to develop, enhance, and integrate their technological pedagogical knowledge effectively (Gerhard et al., 2023). Educators need to have opportunity to learn to familiarize themselves with the TPACK to enable a deep reflection and consideration of their subject expertise and instructional methods through the

perspective of technology. This process is crucial for identifying how TPACK can be specifically applied and interpreted within their particular field of teaching. By doing so, they can effectively integrate technology in a manner that enriches their curriculum and pedagogical approach, tailoring it to their discipline's unique needs and enhancing the overall educational experience (Herring et al., 2016; Krause et al., 2020). Thus, characterizing the OTL for teachers is a crucial step in understanding how best to support their professional development. By identifying and optimizing these opportunities, the aim is to enhance teachers' knowledge and skills, leading to improved teaching practices and better educational outcomes for students.

In educational research, it's common to find studies that examine how teachers develop their knowledge and skills based on a limited scope, often within the confines of a single course or a specific teaching experience (Bauml, 2014; Olson & Craig, 2001). While such studies provide valuable insights, they have a limited scope in that they do not capture the full spectrum of experiences and challenges that teachers encounter in their professional lives. However, a few studies take a broader look across multiple programs, they often focus more on identifying the experiences that preservice teachers have during their training rather than examining how these experiences contribute to the development of their teaching knowledge (Elbaz, 1991). Other studies have employed tools like course syllabi, official documents, and surveys completed by teachers to assess teacher education programs (Ghousseini, 2017; Wang, 1998; Wijaya et al., 2015). But these studies assess the overall effectiveness of teacher education programs, they often do not explore specific opportunities within the programs that contribute to teachers' professional development. This means that while they can gauge the general effectiveness of a program, they may not provide detailed insights into which particular aspects or components of the program. And there has been limited research focusing on how in-service teacher training programs and the

contexts of schools themselves can facilitate the development of teachers' knowledge (McDonnell, 1995). Albano & Rodriguez (2013), for example, is one of the few studies in question concentrates on the learning environments and experiences provided within actual school settings. Several studies have underscored the importance and availability of resources that educators can access to enhance their technological knowledge (Koehler et al., 2007; Graham, 2011). While there are many resources available for teachers' professional development, especially in technological knowledge, there is a lack of detailed understanding of how these resources actually contribute to the development of teachers' knowledge. The dissertation aims to address this gap by conducting a detailed study of the OTL in the TNHE context. It specifically focuses on how OTL within TNHE supports the development of language instructors' TPACK.

Several studies related to how teachers grow and improve their professional competencies (Fahrman et al., 2019; Hordvik et al., 2017; Anderson & Kyzar, 2022; Seung et al., 2012; Nixon et al., 2017; Mikeska et al., 2020; Pando & Aguirre-Muñoz, 2020). Teaching professional training programs are designed to support and develop teachers' knowledge and skills through a structured approach involving lesson planning, instructional strategies, and reflective practice. In the context of language teaching, such training focuses on how to effectively engage students in the learning process, ensuring they develop the necessary language skills in an enriching and supportive environment (Gallagher, 2023; Gao, 2021).

The university environment, especially within TNHE institutions, offers a rich and dynamic context for language instructors to continue developing their teaching knowledge and skills. It provides a range of resources, opportunities for collaboration, professional development programs, and avenues for research and scholarship, all of which contribute to the ongoing professional growth of language instructors (Vereijken & van der Rijst, 2021). In-service teachers have

numerous opportunities to learn and develop professionally outside of formal training programs. These include engaging in everyday teaching practices, utilizing curriculum materials, interacting with educational leaders, collaborating with colleagues, and participating in professional communities. These diverse opportunities support the continuous growth and adaptation of teachers throughout their careers (SAKAMOTO, 2007; Amponsah et al., 2021). Thus, the further discussion will be divided into three distinct sections, each focusing on a different context or aspect of professional learning: professional training, teaching practice, and university context.

2.3.1 Continuous professional development programs

Continuous professional development (CPD) program is a teacher professional development training which refers to the ongoing process through which educators enhance and update their knowledge, skills, and practices to improve their teaching abilities and stay current with advancements in education (Kennedy, 2011). CPD programs in TNHE institutions is a professional training program supporting the knowledge development and teaching practices for TNHE teaching (Compton & Alsford, 2022; Kotuľáková, 2019). Incorporating TPACK in professional development programs can provide in-service teachers with structured and targeted professional development opportunities in technological pedagogical knowledge (Rienties et al., 2013).

The current research method for teacher development training blends the workshop approach with the mentoring approach, recognizing the unique benefits of each (Brush et al., 2003). Workshops are usually led by experts or experienced educators and provide a platform for faculty to learn new concepts, tools, and methods in a collaborative environment. They are often short-term, intensive, and goal-oriented, designed to impart specific skills or knowledge (Polly et al., 2010). Mentoring approach provides guidance, support, and feedback over time, allowing for deeper, context-specific learning and development, as the mentor can tailor their guidance to the

specific needs and circumstances of the mentee (Schaffer & Richardson, 2004). Various forms of CPD programs focusing on TPACK frameworks, instructional design with technology, and effective integration of technology in teaching are essential opportunities to learn for teachers (Doering et al., 2009; Oda et al., 2019). This integration ensures that teachers are exposed to TPACK concepts and have ample opportunities to understand, practice, and develop their TPACK competencies during their CPD.

CPD programs include various formal and informal learning activities, such as workshops, courses, conferences, and self-directed initiatives that contribute to continuous growth and effectiveness in the teaching profession (de Paor & Murphy, 2017). Adequate support systems, including mentoring, tutoring, counseling, and feedback mechanisms, contribute to enhanced opportunities to learn. Learners benefit from guidance and assistance to navigate challenges, clarify doubts, and reinforce their understanding. Take a learner-centuriated perspective, CPD programs in TNHE articulate transnational teachers' learning as situated, social, and distributed (Compton & Alsford, 2022). Practical, hands-on experiences or activities designed for TNHE instructors simulate real teaching scenarios. This implies that these opportunities allow instructors to try out teaching methods, techniques, and tools in a controlled, often innovative setting, providing them with a space to learn and adapt their teaching practices (Burbules & Torres, 2013).

In CPD programs, one approach to professional learning involves experienced teachers studying representations or examples of effective teaching practices (Lamers & Admiraal, 2017). These representations can take various forms, such as video clips, case studies, or written scenarios, and are used as models for teachers to analyze and learn from. For example, teachers watching a video can see firsthand how to engage actively with students, how to facilitate group work, and how to use questioning techniques effectively. By observing and rehearsing these practices,

teachers can develop skills that are directly relevant and beneficial to their teaching. Collaborative activities in TNHE provide instructors with valuable, ongoing opportunities to practice and refine their teaching skills in a supportive and diverse environment. This continual engagement in the practical aspects of teaching, coupled with the benefits of learning from peers and building professional networks, is instrumental in the professional development of TNHE instructors (Keay et al., 2014).

So far, there has been limited empirical investigation into how CPD programs specifically support TNHE instructors' knowledge development, only hypotheses about the potential benefits of these programs, concrete evidence or comprehensive studies are lacking (Borg et al., 2022). Further work is needed for empirical research to understand the actual impact of CPD programs on TNHE instructors' knowledge development, particularly their TPACK.

2.3.2 Pedagogical practices

The development of in-service language teachers is a dynamic process that involves integrating the theoretical and practical aspects of teaching. This combination of educational experiences in training programs and hands-on experiences in the classroom is essential for the development of teaching skills and knowledge (Strasser et al., 2021). This combination of theory and practice is essential for their professional growth and effectiveness as educators. Different from scheduled professional development activities mentioned above, teaching experience and curricula materials are two approaches to TPACK transformation designed to occur within the scope of teachers' daily work, such as writing course or a series of meetings (Herring& Harris, 2016). Online collaborative teaching is an innovative teaching form in TNHE language instruction during COVID-19, which is also an unprecedented experience (Wang, 2023). It encourages instructors around the world to collaborate and share experiences, insights, and best practices related to TPACK to enhance class

efficiency. Engaging in such communities of practice, either physically or through online platforms, allows for peer learning and exchange of ideas on how to integrate technology meaningfully.

Language teachers in TNHE institutions develop and refine their teaching skills through a rich blend of international experiences, peer observation, and collaborative teaching practices (Dhanavel, 2022). These experiences are key to enhancing their pedagogical abilities, adapting to diverse educational contexts, and continually evolving as effective language educators. For example, the activities TNHE language teachers choose to engage in during their teaching play a critical role in their professional knowledge development, which can promote innovation, collaboration, technology integration, and reflection can support growth, while those that do not may hinder it (Howe & Xu, 2013). Also, interactions with students during lessons are a vital source of information for teachers to develop their understanding of students' learning challenges and performance. These interactions not only enhance immediate teaching effectiveness but also contribute to the broader professional growth of teachers by deepening their understanding of student learning processes and needs (Eickelmann et al., 2021). Overall, teaching experiences in TNHE environments are beneficial for developing collaborative skills and technological integration capacity among teachers, there is a noted gap in research specifically examining how these experiences enhance teachers' TPACK development. Addressing this gap is important for optimizing teacher training and support in TNHE contexts.

2.3.3 University context

University contexts offer a variety of resources that could potentially support teachers (Rivera Maulucci, 2013), but there is a lack of detailed research on how these resources specifically contribute to enhancing teachers' knowledge and skills for teaching (Loughran, 2014). When

discussing the instructional environment in the context of TNHE, the focus shifts to the settings, methods, resources, and conditions under which teaching and learning occur across international borders. In essence, the instructional environment in TNHE institutions encompasses not just the physical or virtual spaces where instruction happens but also leaderships, technological tools, and socio-cultural dynamics that influence teaching and learning.

Opportunities to learn are influenced by the design and organization of the educational environment. There are many resources in an instructional environment, including technology infrastructure and accessibility (Light & Pierson, 2013), policy and leadership support (Landa et al., 2023; Major et al., 2021), school culture and values (Lai et al., 2022), community engagement and partnership (McLoughlin & Lee, 2012). The meso level context in the TPACK framework refers to organizational or institutional factors that influence the integration of technology into teaching. The focus here is on the role of university leadership and its attitude towards the use of Information and Communication Technology (ICT) in education. Porras-Hernández & Salinas-Amescua (2013) highlight the significant impact that university leaders' attitudes can have on the successful integration of technology.

The meso level context in the TPACK framework refers to the organizational or institutional influences on the integration of technology into teaching, with a particular focus on the role of university leadership. According to Porras-Hernández & Salinas-Amescua (2013), the attitude and support of university leaders towards the use of Information and Communication Technology (ICT) for learning are crucial. A positive and supportive attitude can encourage and facilitate the use of technology, leading to more effective integration of ICT in teaching and learning processes. Conversely, a poor attitude or lack of support can act as a significant barrier, hindering teachers' ability to integrate technology into their pedagogy (Porras-Hernández & Salinas-Amescua, 2013).

Leadership has a direct and influential role in either facilitating or impeding the integration of technology in teaching. For instance, in 2011, the American Association of Colleges for Teacher Education's (AACTE) Innovation and Technology Committee started identifying leadership modules and formative assessments specifically for teacher education leaders. The goal was to transform teacher preparation programs to fully embrace and effectively utilize TPACK principles (AACTE Committee, 2014).

Though there is existing research on the impact of school resources on teaching practices, there is a gap in understanding how these resources, along with leadership support, specifically contribute to the development of teachers' TPACK and overall knowledge in the context of TNHE. There are various aspects of school resources that have been the focus of research, such as support from colleagues, availability of adequate resources, staff stability, (Jones, 2017), or hardware, software, and platforms that necessary enablers for educators to experiment and build their technological knowledge (TK) within the TPACK framework (Ohlemann et al., 2023). During COVID-19, when language teachers do engage in teaching, but perceive the environment as less supportive of virtual or technologically integrated instruction, they tend to rely more on traditional, perhaps more familiar, instructional strategies (Sumba-Nacipucha et al., 2021). This reliance on traditional methods, in the absence of a supportive environment for technology use, indicates a missed opportunity for utilizing more innovative, technologically enhanced teaching approaches. Thus, in TNHE settings that are conducive to the use of technology, language teachers find more opportunities to enhance their skills and knowledge in integrating technology with pedagogy and language content.

In summary, opportunities to learn in TPACK building encompass a range of experiences, resources, and professional development initiatives that enable educators to enhance their TPACK

competencies. The goal for teachers, particularly in TNHE settings, is to effectively integrate technology with pedagogy and content knowledge. This integration is crucial for optimizing educational outcomes. However, previous research on how learning opportunities in professional training programs and instructional environments support teachers' TPACK development is described as narrow in scope. While a substantial amount of research might focus on curriculum development and professional training programs in TNHE settings, there's a noted scarcity of studies that explore other forms of learning opportunities within these instructional environments. There is an exception in curriculum and professional development, Angeli & Valanides (2009) and Golonka et al. (2012) explored how the design and use of curriculum materials or structured professional development programs can contribute to knowledge growth and better teaching in TNHE contexts. Thus, there is a need for broader and more comprehensive research that examines a wider range of learning opportunities in TNHE environments and how they specifically contribute to teachers' TPACK development.

3. Methodology

3.1 A Summary of research design

The main research objective (MRO) of this dissertation is to build instructors' technological pedagogical content knowledge (TPACK) through identifying the opportunities to learn (OTL) that support language instructors' TPACK development in TNHE context. In order to investigate opportunities to learn which supports language instructors' TPACK development in TNHE context, the research conducts a mixed-longitudinal method.

To achieve this overarching purpose, this research has two sub-objectives: the first sub-objective (SRO1) is to explore and understand the changes and developments through a validated tool in TPACK of language instructors during the specific timeframe of the COVID-19 pandemic;

the second sub-objective (SRO2) is to analyze how instructors develop TK, PK, CK and TPACK from OTL perspective, including professional training programs, pedagogical practices, instructional environments. While achieving SRO2 will generate a list of factors influencing instructors TPACK in teaching during COVID-19, the fulfillment of SRO1 will provide a framework to characterize opportunities to learn and thus guide language instructors to build TPACK. Achieving these two sub-objectives will fulfill the MRO.

In Study 1, the research modifies the well-established survey tool developed by Schmidt et al. (2009) to align with the context of language instructors in TNHE institutions. Though the work of Schmidt established the validity and reliability of a specific research instrument, but there has yet to be a valid and reliable TPACK survey developed for TNHE language instructors specially. Additionally, technology is valued in language teaching for specific and unique types of learning activities. For example, during COVID-19, social media such as WeChat is promoted as a way for learners to use language in a meaningful way while constructing knowledge with other learners. A qualitative approach is employed to investigate the development of TPACK among language teachers. The research begins with an adapted scale instrument, utilizing descriptive statistics, correlation analysis, reliability testing, and confirmatory factor analysis (CFA) to analyze TPACK indicators. This is complemented by structural equation modeling (SEM) to explore the relationships between TPACK components. A longitudinal pretest-posttest design with Repeated Measures ANOVA is conducted with a subset of 167 participants. The application of ANOVA enables the investigation of changes in TPACK competencies over time, thus capturing the dynamic nature of these competencies in the educational context.

In Study 2, after highlighting the changes in TK, PK, CK and TPACK by quantitative approach in Study 1, the research question in Study 2 is: what learning opportunities are provided

within the various components of the educational landscape? A longitudinal case research will be conducted to provide deeper insights into the reasons behind these changes, which give a more holistic understanding of situation during COVID-19. The research is conducted by focusing on three language instructors. This longitudinal case study involves an in-depth exploration of three cases over three consecutive semesters (Spring Semester 2020, Fall Semester 2020, Spring semester 2021) to observe changes and understand the reasons behind them. The researcher uses a longitudinal case study approach to investigate TNHE instructors' TPACK development in OTL contexts, including continuous professional development programs, teaching practices and university contexts.

Table 1 Outline of research, design, process, and outcome

	Research Question	Procedure	Analysis	Test
Study 1	1: To what extent do TPACK, TK, PK and CK are identified as four inter correlated dimensions' measures?	Panel review the adapted instrument for content validity EFA test (n=262)	A refined version of the adapted survey instrument Bartlett's Test of Sphericity; Kaiser-Meyer-Olkin (KMO) Measure Cronbach's Alpha; factor loading; Convergent Validity Comparing models	Reliability and validity of measures TPACK self-assessment measurement model
	2: To what extent CK, PK and CK affect language instructors' technology integration (TPACK)?	CFA test (n=234) SEM model test (n=234)	CFI & TLI, RMSEA & SRMR	TPACK prediction model
	3: Were there developments in TK, PK, CK and TPACK over three consecutive semesters?	Analysis of pretest and posttest data (n=167) using repeated measures ANOVA	Cronbach's Alpha significant change (F Value) partial eta squared	Developments in TPACK across groups difference over time
Study 2	1: How does language instructors' TPACK for language teaching develop in their teaching practice during COVID-19?	Content analysis, frequency comparison	A collection of qualitative data from class observation and follow-up interviews; Visualization of changes within TPACK and its domain in case.	TPACK and its domain changes by individual
	2. What learning opportunities are provided in CPD,	Describe what constitutes a learning	A collection of qualitative data from interviews, documents	themes of OTL within CPD programs,

	teaching practice and university contexts to support the development of their CK, TK, PK and TPACK for teaching?	"opportunity" in the context of TNHE language education; Elaborate on the elements of professional training, teaching practices, and university context.	and class observations; Thematic analysis	teaching practices, and university contexts
	3: How do the opportunities provided for TPACK development in the CPD programs, teaching practice and the university environments relate to the actual TPACK expertise language teachers exhibit in their classroom practice?	Identify individual development in TPACK from OTL perspective	Case analysis	OTL in individual TPACK development

3.2 Study 1 Sampling, data collection and analysis

3.2.1 An overview of Study 1

Study 1 adopts a quantitative methodology with a focus on knowledge "for" the context of language teaching. The study begins by examining how three foundational knowledge bases—TK, PK, and CK—influence the development and effectiveness of TPACK. Further, it assesses how TPACK evolves over an extended period. This longitudinal approach provides insights into the dynamics of TPACK development. TPACK is the key component needed for instructional

practices to enhance students' language competencies. To achieve the objectives of the study, three research questions were developed:

1. What are interrelationships among the various components of the TPACK framework in the context of language instruction?

2. To what extent do TK, CK and PK impact on language instructors' TPACK?

3. How did TK, CK, PK and TPACK change over three consecutive semesters?

3.2.2 Participants and sample size

The participants in this study are language instructors from Chinese TNHE institutions.

The study uses Exploratory Factor Analysis (EFA) to uncover the underlying structure of variables. EFA is a statistical method used to uncover the underlying structure of a large set of variables (Watkins, 2018). Given the nature of EFA, a larger sample size is often required compared to confirmatory factor analysis (CFA) (Kyriazos, 2018; Sürücü et al., 2022). This is because EFA is exploratory and seeks to identify patterns within the data without pre-imposed constraints or hypotheses about the factor structure. Thus, the EFA sample consists of 262 valid participants, who are language instructors from twelve Chinese TNHE institutions. This sample size is considered adequate for conducting EFA. Demographic information and other relevant details about these participants are presented in Table 2. The participants focus with 5-10 years of working experience in this study. China's transitional higher education has approximately two decades of history. Also, many instructors do not have opportunities for academic advancement within this specific sector. Consequently, they accumulate a certain level of working experience before seeking more favorable positions elsewhere.

Table 2 Demographic information of EFA participants

	N	Percent(%)	Cumulative Percent(%)
Gender			
Male	94	35.9	35.9
Female	154	58.8	94.7
Not tell	14	5.3	100.0
Education			
Bachelor's degree	39	14.9	14.9
Master's degree	213	81.3	96.2
Doctorate	10	3.8	100.0
Years of experience			
Less than 1 year	10	3.8	3.8
1-5 years	185	70.6	74.4
6-10 yeas	55	21.0	95.4
Over 11years	12	4.6	100.0
Primary Mode of Instruction during COVID-19			
Fully online	81	30.9	30.9
Hybrid	181	69.1	100.0
Technological tools familiarity prior to COVID-19			
Extensive	19	7.3	7.3
Moderate	57	21.8	29.0
Limited	178	67.9	96.9
None	8	3.1	100.0

The sample in CFA are different participants from the other ten TNHE institutions in China based on their geographical distribution: Southampton International College at Dalian Polytechnic University, Houston International Institute at Dalian Maritime University, TDU at Beijing University of Technology, Beijing University of Posts and Telecommunications Queen Mary University of London Joint Degree Programme, Shanghai Jiao Tong University SJTU-UM Joint Institute, Shanghai University of Finance and Economics, University of Central Lancashire Joint

Programme, University of Nottingham Ningbo China, Missouri Institute at Xiamen University of Technology, and Institute of Creativity and Innovation at Xiamen University. The language instructors who participated in the survey were Chinese teaching faculty in TNHE who have taught during the COVID-19.

The study involved a sample of male and female participants aged between 28 and 54 who voluntarily took part in a survey. The valid post responses from 234 respondents were used to validate a TPACK measurement tool and to test a predictive model during the Spring Semester of 2021. This approach aims to ensure the reliability and effectiveness of the TPACK measurement in an educational research context.

In order to determine if there are differences between means across semesters, a repeated measures ANOVA analysis is conducted. The semester chosen for the repeated ANOVA analysis was based on having an adequate number of respondents before (pre) and after (post) a particular intervention or time period. The pre-survey, conducted in the Spring Semester of 2020, had a total of 234 valid respondents. The post-survey, conducted in the Spring Semester of 2022, had a total of 167 valid respondents. The reduction in numbers from the pre-survey to the post-survey were due to various reasons, including job leaving or choosing not to continue with the study. Thus, out of the initial 234 participants, 167 met the inclusion criteria for the full analysis, meaning they provided complete and valid responses for both pre and post surveys. The number of these paired respondents is noted as 167 (Table 3), which is the final sample size used for the statistical comparison. The survey data was collected using email.

The study focused on semesters with sufficient pre and post survey responses for analysis. Out of the total respondents, 234 participants met the study's inclusion criteria. Thus, the pre-survey was conducted in the Spring Semester of 2020, there were 234 valid respondents (n=234).

The post-survey, conducted in the Spring Semester of 2022, had 167 valid respondents (n=167). So, the total number of participants who responded to both the pre and post surveys (paired respondents) was 167. Repeated measures ANOVA (Analysis of Variance) is used to compare means across different time points within the same group of participants. The survey was conducted as part of an assessment of instructors' TPACK in their teaching. The survey was conducted to assess instructors' TPACK at start of semester and end of semester (Spring Semester 2020, Fall Semester 2022 and Spring Semester 2021). This timeframe allowed for the examination of changes or trends over time.

In summary, the study involved conducting repeated surveys (pre and post) across different semesters to assess language instructors' TPACK in their teaching. A total of 234 participants met the inclusion criteria for the study, with 167 respondents providing paired data necessary for Repeated Measures ANOVA analysis. The surveys were conducted online during language instruction across three specified semesters.

Table 3 Demographic information of CFA participants

	N	Percent (%)	Cumulative Percent (%)
Gender			
Male	80	34.2	34.2
Female	144	61.5	95.7
Not tell	10	4.3	100.0
Education Qualification			
Bachelor's degree	26	11.1	11.1
Master's degree	198	84.6	95.7
Doctorate	10	4.3	100.0
Years of Experience			
Less than 1 year	4	1.7	1.7
1-5 years	156	66.7	68.4
6-10 years	61	26.1	94.4

11-20 years	13	5.6	100.0
Primary Mode of Instruction during COVID-19			
Fully online	91	38.9	38.9
Hybrid	143	61.1	100.0
Technological tools familiarity prior to COVID-19			
Extensive	10	4.3	4.3
Moderate	75	32.1	36.3
Limited	140	59.8	96.2
None	9	3.8	100.0

3.2.3 Instrument adaptation

The Schmidt et al.'s (2009) TPACK self-report instrument within a specific research study focused on pre-service teachers' self-efficacy. It includes four subjects, including mathematics, science, social studies, and language subject areas. In this study, items that only related to language content were used from the original Schmidt's et al. (2009) survey. Some research were able to identify TK, PK, CK, PCK, TCK, TPK and TPACK (Abbitt, J. T., 2011; Cox, S., & Graham, C. R., 2009). Previous studies, as mentioned by Abbitt (2011) and Cox & Graham (2009), faced difficulties in identifying all seven constructs of the TPACK framework in different contexts. This suggests that some contexts or subjects might not align perfectly with the original structure of the TPACK survey. In response to these challenges, the current study focuses specifically on the technological, pedagogical, and content knowledge related to language teaching. Therefore, this study modified items from confirmed four factors--- TK, CK, PK and TPACK. The questionnaire is 5-point Likert scale (Appendix A). The scale ranged from 1 (strongly disagree) to 5 (strongly agree).

TK Construct. TK means language instructors' self-assessment in applying technology in their teaching activities. For example, "Adapting to new technology tools used for language instruction comes naturally to me."

PK Construct. PK is teaching strategy self-assessment that language instructors utilize in their language classroom. For example, “I have expertise in teaching English listening skills, enabling students to understand and interpret spoken English in diverse scenarios, from everyday conversations to academic lectures.”, “I employ multiple assessment strategies to gauge the language comprehension of my students.”

CK Construct. CK refers to language content self-assessment. For example, “I possess skills in teaching English writing, from basic sentence construction to composing advanced essays and reports.”

TPACK Construct. TPACK refers the intersection of knowledge domains of language instructors in TNHE language teaching. It includes five items. For example, “My teaching approach adeptly combines linguistic content, relevant technologies, and pedagogical strategies suitable for transnational education.”

3.2.4 Analysis procedure

RQ1: EFA and CFA for TPACK Dimensions

Reliability and validity of adapted instrument

The original survey instrument (Schmidt et al., 2009) are modified based on literature review, aiming at achieving a more robust and contextually relevant measurement of TPACK (Baser et al., 2016; Chai et al., 2011; Ching et al., 2010; Kaya Da, 2013). Then the content of items was reviewed by experts, including three teacher educators. They assessed the measurement content to determine whether they appropriately assess TPACK and its domains, and if the items accurately represent the constructs they aim to measure.

Then a EFA is conducted to determine items, thereby contributing to the construct validity of the instrument, assisting in validating the constructs that adapted instrument is supposed to measure.

Since this research involved a thorough analysis using CFA to validate measurement, it began with item-level descriptive statistics and correlation analysis, followed by examining data normality through univariate analysis and distribution plotting, focusing on skewness and kurtosis.

Based on TPACK framework, tour components (TK, CK, PK, and TPACK) are conceptualized as distinct yet interrelated dimensions, forming a four-dimensional model. This model is hypothesized to capture the complex interplay of technology, pedagogy, and content knowledge in educational settings.

CFA is conducted to test whether the data fit a hypothesized measurement model. It is used here to validate the four-dimensional structure of the TPACK model. In CFA, each dimension (or factor) is represented by various observed variables (indicators), and the analysis assesses how well these factors explain the correlations among these indicators (Brown, 2015). Mplus was used to analyze both CFA and SEM (Muthén & Muthén, 1998-2015).

To evaluate the model fit, the actual data is evaluated by using the following indices:

Confirmatory Fit Index (CFI) and Tucker-Lewis Index (TLI) compare the fit of the user-specified model to a baseline model. Values closer to 1 indicate a better fit, with values above 0.90 or 0.95 often considered indicative of a good fit (Bentler, 1990; Hu& Bentler,1999; Ticker& Lewis, 1973).

Root Mean Square Error of Approximation (RMSEA): This index assesses the fit per degree of freedom in the model, with lower values (typically less than 0.06 or 0.08) indicating a better fit (Hu& Bentler, 2019; Steiger, 1999).

Standardized Root Mean Square Residual (SRMR) is to observe the standardized difference between the observed correlation and the model-predicted correlation. A value less than 0.08 is generally considered good (Hu& Bentler, 1998; Kline, 2015).

Pearson's correlation coefficient is also checked for significant values in the hypothesized latent factors and addressed singularity and multicollinearity concerns. This correlation is typically quantified using which ranges from -1 to +1. The threshold of 0.85 is a commonly used benchmark in research to gauge the degree of correlation between predictors (Tabachnick, 2013). Maintaining correlation values below 0.85 between distinct predictors in a model is a practice aimed at ensuring that each predictor contributes uniquely to the model, thereby reducing multicollinearity and improving the model's overall validity and reliability.

The study also compared to a unidimensional TPACK model (see Figure 4 and Figure 5), as suggested by some studies (Abbitt, 2011; Archambault & Barnett, 2010). This comparison was made using various statistical measures for fit indices.

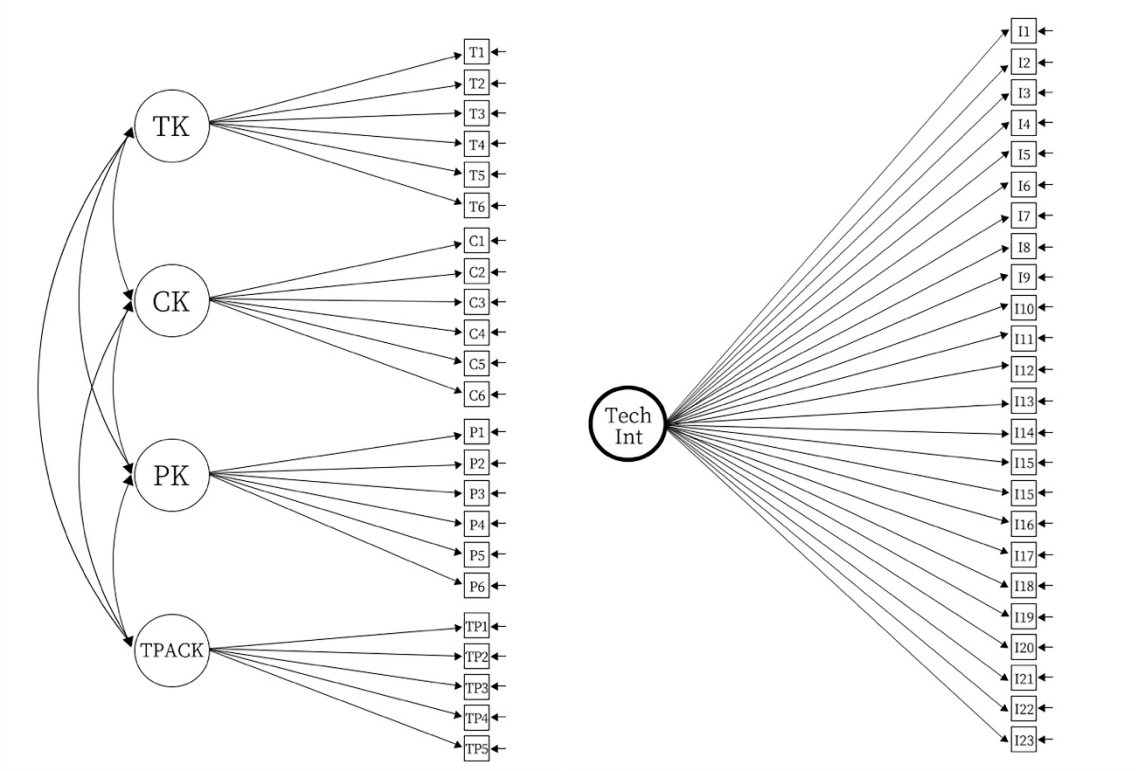

Figure 4 A four-factor correlated TPACK model

Figure 5 A unidimensional TPACK model Research Question Two: SEM Analysis

RQ2: SEM analysis

To test whether TK, CK, and PK positively predict TPACK, Robust Maximum Likelihood estimation (MLR) in the context of CFA and SEM.

The process involves a series of steps in SEM, specifically focusing on addressing data normality issues, validating measurement models, and testing a predictive result.

Non-normality in the data is addressed using Robust maximum likelihood estimation (MLR), which enhances the robustness and reliability of parameter estimation in complex statistical models like SEM (Brown, 2015). This is crucial for ensuring the accuracy and reliability of the model's results.

The Sequential reporting of results is systematically calculated from the results of measurement models (CFA) and the results of the structural model (the full SEM analysis). Initially, the results from the measurement models are reported. This step involves CFA to validate how well the observed variables represent the latent constructs to measure. Validating the measurement models is crucial before proceeding to the structural model because it ensures the constructs are measured reliably and validly. After confirming the adequacy of the measurement models, the full SEM was analyzed and reported. The relationships between the constructs (as hypothesized in the research) are tested, and the structural model includes path analysis, where direct and indirect relationships between variables are examined.

Then, the SEM analysis was used to test the RQ2. In this model (see Figure 6), TK, CK, and PK are treated as independent variables, and their predictive power on TPACK (the dependent variable) is examined.

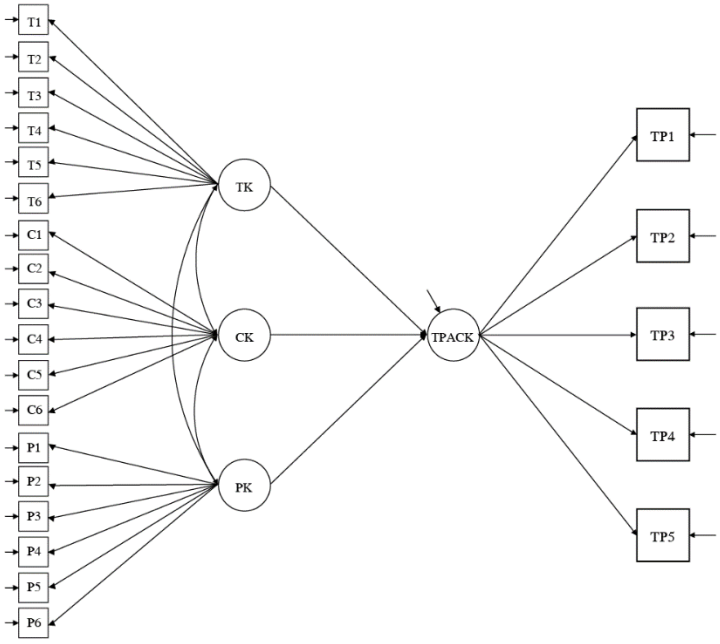

Figure 6 TPACK conceptual model

Model fit is assessed by indices. In CFA, the fit indices (e.g. CFI, TLI, RMSEA, SRMR) help determine how well the measurement model fits the data. Subsequently, in SEM, these fit indices are again evaluated to understand how well the overall model, including both measurement and structural components, fits the data. Component fit are also calculated, including specific path analysis, parameter estimates, standard errors (SEs) and p-values, test the significance of the relationships, with p-values indicating whether the findings are statistically significant.

RQ3: Repeated Measures ANOVA

To determine development trends in TK, CK, PK and TPACK over one semester, and to identify if these changes varied across Spring Semester 2020, Fall Semester 2020, Spring Semester 2021.

Repeated Measures ANOVA is applied as a key analytical tool to examine changes in TPACK and its domains across three consecutive semesters using pre- and post-survey data, applying.

The study collected data in Spring Semester 2020, Fall Semester 2020, Spring Semester 2021, yielding a paired sample size of n=167.

Repeated Measures Analysis is suitable for longitudinal studies to examine participant changes over time, even over relatively short-term periods like academic semesters. It is also efficient with limited participants, reducing variability and enhancing result validity (Field, 2013). The study conducts a Repeated Measures ANOVA analysis using the General Linear Model in SPSS, considering three factors across subjects (different semesters) and two factors within subjects (data collected before and after a semester).

Before conducting the Repeated Measures ANOVA, Cronbach's Alpha (α) is used to assess the constructs' internal consistency. A Cronbach's Alpha of 0.7 or above is generally considered

acceptable (Cronbach, 1951). Homogeneity of variance are tested by Levene's Test, checking if the variances for each group are statistically significantly different from each other. A non-significant Levene's test ($p > 0.05$) suggests that the assumption of homogeneity of variances is not violate (Levene, 1960).

The F-ratio and p-value are used to make decisions about whether the hypotheses being tested, which determine whether the differences between group means are statistically significant. The F-Ratio (F) and its corresponding significance level (p-value) were presented. A p-value below 0.05 indicates that the findings were statistically significant and not merely random occurrences, as explained by Cohen (1994). Additionally, the extent of the difference between pre and post measurements was determined using Partial Eta Squared (η^2), with established benchmarks for small ($\eta^2 = 0.01$), medium ($\eta^2 = 0.06$), and large effects ($\eta^2 = 0.14$).

In summary, RQ3 uses Repeated Measures ANOVA to assess changes in TPACK and its domains over time and across different semesters, ensuring the robustness of the analysis through preliminary tests and detailed reporting of statistical results.

3.3 Study 2 Sampling, data collection, and analysis

3.3.1 An overview of Study 2

Study 2 adopts a case study methodology emphasizing on knowledge "in" the context of language teaching. A longitudinal case study is a research method that involves the detailed, in-depth examination of a case or cases over a period of time (Yin, 2018). In a longitudinal case study, data are collected at multiple points in time. This allows the researcher to observe changes and developments as they occur, to understand the temporal sequence of events, and to analyze the evolution of the case(s) being studied. The longitudinal design is particularly useful for

investigating processes and for seeking to understand cause-and-effect relationships within a particular context.

The principal aim is to investigate the development of TPACK and its sub-domains in CPD programs, practice and university contexts during the COVID-19 pandemic. This research examines the practices of three instructors in TNHE institutions to understand how their TPACK develops amidst the challenges posed by the pandemic. The case studies are designed to not only illuminate the distinct experiences by detailing the pivotal aspects of each case within its particular context but also to place a significant focus on the interactions that take place during the actual process of teaching, as emphasized by Stake (2000). These interactions are critical for appreciating the dynamic application of TPACK in educational practice. The majority research on the development of TPACK published come from self-reported data (Schmidt et al., 2009; Archambault & Bartnett, 2010; Chai et al., 2013). Self-report data, which indicate teachers' knowledge "for" teaching, does not automatically imply they can utilize that knowledge in their practical application. Thus, it is important to utilize mixed data in order to track TPACK development.

3.3.2 Research questions

The research questions for Study 2 are outlined below:

1. How does language instructors' TPACK for language teaching develop in their teaching practice during COVID-19?
2. What learning opportunities are provided in CPD, teaching practice and university contexts to support the development of their CK, TK, PK and TPACK for teaching?

3. How do the opportunities provided for TPACK development in the CPD programs, teaching practice and the university environments relate to the actual TPACK expertise language teachers exhibit in their classroom practice?

3.3.3 Recruitment of participants

Three language instructors invited to participate in this study were randomly selected from Southampton International College, University of Nottingham Ningbo China, and Institute of Creativity and Innovation at Xiamen University. The study only focuses on these three instructors who participated throughout three consecutive semesters of teaching (Spring Semester 2020, Fall Semester 2020, Spring Semester 2021): Lily, Tom and Lucy. To protect the privacy and confidentiality of interview participants, all real names of the interviewees have been replaced with pseudonyms in the analysis of the interview results in this study. The demographic information of participants is presented in Table 4.

Table 4 Demographic information of participants in Study 2

Participants	Age	Gender	Nationality	Affiliation	Education	Teaching experience
Lily	32	Female	China	SIC	Master's degree	3 years
Tom	37	Male	China	Ningbo Nottingham University China	Master's degree	6 years
Lucy	45	Female	UK	Institute of Creativity and Innovation at Xiamen University	Master's degree	10 years

3.3.4 Data sources and analysis

The data sources came from language instructors' teaching practices, interviews and CPD programs during COVID-19. The data from both observations, interviews, CPD programs files were then disaggregated into "units of meaning" (UoMs), which serve as the primary data segments for coding. Drawing from Mohan's (2007) concept of "activity" as a social practice, the data were further divided into Units of Meaning (UoMs), which served as the basic elements for open coding. The data were organized into individual "data sets" for each participant, consisting of digital files from data collection. These UoMs were identified and analyzed based on the framework of an activity as conceptualized by Mohan (2007), which links language use to the functions and purposes within the educational context. This segmentation facilitates a more manageable and systematic approach to coding, which is the process of categorizing and labeling the data for thematic analysis.

Table 5 is an overview of collected data sources for each instructor from Spring Semester 2020, Fall Semester 2020, Spring Semester 2021.

Table 5 Overview of total data sources across all three instructors

Sources	**Occurrence rate**		
	Spring Semester 2020	Fall Semester 2020	Spring Semester 2021
RQ1: How does language instructors' TPACK for language teaching develop in their teaching practice during COVID-19?			
Class observation of language teaching	1	1	1
Instructors' follow-up interview about teaching	1	1	1
RQ2: What OTL are provided in a CPD program, teaching practices and university contexts to support TPACK development?			
Course syllabi and PPTs of CPD		1	
Class observation of language teaching	1	1	1
Interviews with administrators	1	1	1
Interviews with instructors	1	1	1
RQ3: How do the OTL provided for TPACK development in the CPD programs, teaching practices and the university environments relate to the actual TPACK expertise language teachers exhibit in their classroom practice?			
Data from RQ1 and RQ2			

RQ1 data collection and analysis

The research design incorporated direct classroom observations and follow-up interviews to gather data on language instructors' TPACK and frequency is used for textual data content analysis (Krippendorff, 2018).

Observation protocol

Each observation session was conducted by the researcher, who utilized an established observation protocol to ensure consistency and comprehensiveness in data collection. In the

classroom setting, the researcher noted observable practices, technology use, pedagogical interactions, and content-related discussions. Any inquiries or reflections that arose during the observation were also recorded to inform subsequent data analysis and interview questioning.

Interview guide

Following the observations, interviews with the participants were conducted using a set of pre-formulated questions designed to probe deeper into their TPACK experiences.

The interview is instrumental in facilitating a reflective process among the participants. The protocol furnished a set of one to two prompting questions for each domain (see Appendix B). These questions serve to direct attention to key elements of the teacher's instructional practice and to maintain the focus of the observation on relevant aspects of the TPACK framework. This protocol allows for both structured and open-ended observation, ensuring that observers can capture a comprehensive picture of the instructor's practice (Angelo, 1993). Before observations, a brief lesson plan was obtained from the teachers to provide context for the observer, enabling her to better understand and evaluate the instructional activities in light of the lesson's objectives and content. During the observation, the protocol also allowed observer to raise emergent questions that arose while witnessing the teaching in action. These questions were intended for use in follow-up interviews to clarify and explore deeper into specific instances of teaching practice observed, thus enriching the data collected (Duff, 2008; Gillham, 2008; Niess, 2011).

The codebook (see Table 6) for content analysis (Krippendorff, 2018) is based on "units of meaning" (UoMs), which serve as the primary data segments for coding. Then frequency analysis is conducted by a bar chart representing the frequency of codes related to the TPACK framework to understand each TPACK knowledge domain occurrence in consecutive three semesters, offering a statistical longitudinal development of the prevalence of these domains within the teaching

practices observed. Frequency analysis is a common and valuable tool in content analysis, particularly for providing a quantifiable dimension to the analysis (Krippendorff, 2018). This is also a complement to qualitative examination in Study 1 RQ3.

Table 6 Codebook for class observation

UoMs	**Descriptions of content**	**TPACK domains**
Utilization	The instructor employs technological resources and/or educational strategies for instructing on subject matter.	TK PK CK TPACK
Alignment	The instructor chooses appropriate technological tools and/or teaching methods to achieve the objectives of the lesson.	
Preparation	The instructor exhibits proficiency in applying technology and/or instructional strategies in preparation for teaching content.	
Collaboration	The instructor collaborates with colleagues to integrate technology and/or instructional methods in the delivery of educational content.	
Engagement	The teacher uses technological tools and/or instructional techniques to actively involve students in the learning of subject matter.	
Learner-centered	The educator leverages technological resources and/or instructional methods to establish an environment focused on the students, tailored for effective content assimilation.	
Reflection	The instructor critically reflects on the pedagogical effectiveness and/or technological integration in the delivery of language instruction remotely.	
Problem-solving	The instructor demonstrates proficiency in identifying and resolving impediments to maintain instructional continuity.	
Connectivity	The instructor employs technological tools and/ or pedagogical strategies to facilitate connections	

	between students' learning experiences and those of others.
Knowledge transfer	The instructor facilitates the transfer of language learning technological skills across various digital contexts and applications.
Integration	The instructor synthesizes technological and/ or pedagogical methods to enhance language acquisition, leveraging digital immersion techniques.

RQ2 data collection and analysis

To categorize the data based on different learning opportunities for analysis purposes, various data sources, including class observations, interviews (with instructors and administrators), syllabi (CPD programs), lesson plan (CPD programs) and PowerPoint slides (CPD programs) are categorized units of meaning (UoM) (Mohan, 2007). Braun and Clarke's (2007) six phases of thematic analysis are used for identifying, analyze and report the OTL in CPD programs, teaching practice and university contexts.

CPD programs overview

To develop practical skills in using digital tools to foster interactive and engaging learning experiences, the School of Education of University of Southampton provided a 10-hour online CPD courses in 2020 Semester Fall to Dalian Southampton International College, encouraging active engagement, provide opportunities for collaboration, and offering practical experiences to help language tutors effectively develop and apply TPACK in their teaching methodologies. And Nottingham university delivered online a 12 hours CPD program to the University of Nottingham Ningbo China, aiming to leverage the expertise of the University of Nottingham while being mindful of the challenges and the context of the Chinese educational partnership during the COVID-19 pandemic. Given the COVID-19 restrictions, Institute of Creativity and Innovation at

Xiamen University delivered a blend of synchronous (live Teams, online workshops) and asynchronous (recorded lectures and resource sharing) CPD program to enhance instructors' teaching effectiveness during COVID-19.

The data source of CPD program collected in Study 2 includes course syllabi, PPTs and teaching plans. The contents in courses are illustrate in Appendix 4-6. These CPD courses help instructors understand the TPACK framework and its relevance in instruction. It also helps to understand the interplay between technological knowledge, pedagogical knowledge, and content knowledge in teaching. The courses also encouraged active engagement, provide opportunities for collaboration, and offer practical experiences to help language tutors effectively develop and apply TPACK in their teaching methodologies.

During the three consecutive semesters of their teaching careers, language teachers were engaged in an interview scheduled at strategic times. These interviews were integral to a longitudinal study tracking the development of their TPACK.

Teaching practice overview

OTL is also defined as a classroom-focused teacher effect and asserted that it is a central instructional construct worthy of educational researchers' and teachers' attention. This means opportunity to learn always happened in an instruction scenario. However, teaching practice is not a typical instruction scenario for teachers' knowledge development. As an important integral part of teachers' knowledge transfer and flow, this study includes the teaching practice to explore any implicit chances of knowledge development among instructors.

Observation protocol

The researchers would review the lesson plan and other class materials before class observation. In order to collect high quality evidence that captures the observed opportunity to

learn for teachers' TPACK development, the observation protocol (see Appendix 7) is designed to collect various opportunities available for teachers to develop their skills and knowledge in the TPACK framework. It focuses on real-world classroom scenarios, professional development activities, and support systems that contribute to the growth of teachers in integrating technology, pedagogy, and content knowledge in their teaching practice.

Interview guide

Through carefully crafted questions, the instructors were encouraged to introspect and reflect their learning opportunities from teaching, particularly the integration and impact of technology in their lessons (see Appendix 8).

Also, some learning opportunities may not be observed from teaching class, because teaching practice is a main form of TPACK utilization, instead of TPACK development. Also, sometimes utilization may mean developing. So, questions related to their reflection or activities which related to teaching practice after class such communication with collaborative peers. Because collaboration teaching is a creative form in TNHE institutions during COVID-19, there are also some questions related to teaching practice related communication after class, such as "What do you think collaborative teaching? What did you learn from your peer?" and "What changes would you make after you communicate with your peer?" serve to initiate a critical self-reflection process. These questions encourage educators to engage in a reflective practice, a cornerstone of professional development in teaching. They provide a chance for teachers to critically find out how they develop their TPACK knowledge from their practice, identify areas of success and improvement, and contemplate future modifications to enhance their teaching.

University context overview

A university that focuses on providing opportunities for instructors' development in the TPACK framework will offer a comprehensive support system that includes professional development, access to resources, collaborative learning environments, support for pedagogical innovation, and a culture that values continuous learning and adaptation. Thus, the data collected in university context include interviews with instructors and administrators. Appendix 8 and Appendix 9 are respective interview guide for instructors and administrators.

After all data collected, Braun and Clarke's (2007) six phases of thematic analysis is used for exploring OTL. Upon individual coding, two researchers compared their results and convened discussions to achieve consensus on the assigned codes, as well as to establish new codes as warranted by the data. In instances where agreement could not be reached, a third researcher conducted blind coding, and the trio would then engage in deliberation to finalize the coding for the disputes. This meticulous procedure was replicated for the "data sets" of all participants (Elo & Kyngäs, 2008). The recursive nature of the analysis meant that two coders continuously revisited previous analyses, adjusting and refining the codebook (Appendix 11) as needed. This dynamic approach ensured a rigorous and reflective engagement with the data, fostering a deepened understanding of what motivate teachers to integrate TPACK domains into their pedagogy.

4. Results of Study 1 (RO1)

The results for the three research questions, as detailed in Chapter 3 of Study 1, are discussed therein.

4.1 RQ1 Result

4.1.1 EFA analysis

EFA is conducted to explain the pattern of correlations within a set of observed factors. Table 7 presents the results of a rotated component matrix with varimax rotation. In this matrix, the variables (TK1, TK2, ..., TPACK7) are adapted questionnaire items, and the factors (1, 2, 3, 4, 5) represent the extracted factors after rotation. Generally, loadings above 0.4 or 0.5 are considered strong enough to contribute meaningfully to a factor. Loadings below this threshold often indicate that the item has a weak association (Hair et al., 2010). Thus, both PK7 with a loading of .109 and TPACK5 with a loading of .052 have weak association. This is significantly below the threshold, suggesting a very weak association. TPACK2 has a loading of -0.029 on Factor5, indicating a negligible association. These three low factor loadings are removed from dataset and factor analysis is re-run.

Table 7 Rotated component matrix results

	Component				
	1	2	3	4	5
TK1	-.009	.264	.748	.023	.068
TK2	.060	.135	.767	.032	.137
TK3	.165	.120	.684	.038	.060
TK4	.015	.112	.825	.005	-.121
TK5	.121	.044	.819	.046	.115
TK6	-.004	-.022	.727	.002	-.023
CK1	.822	.111	.098	.084	.026
CK2	.793	.185	.072	.008	.005
CK3	.811	.055	.067	.061	-.074
CK4	.760	.074	.054	.074	.030
CK5	.755	.076	.047	-.006	.214
CK6	.766	-.030	.006	.017	.041
PK1	.109	.716	.101	.063	.146
PK2	.120	.807	.070	.027	-.046
PK3	.068	.761	.116	.087	-.047

PK4	.064	.627	.107	.037	.213
PK5	.021	.793	.091	-.011	.003
PK6	.069	.842	.101	.002	-.011
PK7	.062	.109	.085	.105	.690
TPACK1	.033	.031	.078	.729	.185
TPACK2	-.029	.019	.115	-.011	.584
TPACK3	.094	.012	.006	.765	-.038
TPACK4	.016	-.037	.041	.799	.075
TPACK5	.091	.020	-.053	.052	.497
TPACK6	.004	.147	-.026	.763	.046
TPACK7	.060	.030	.029	.754	-.045

Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Table 8 depicts the new factor loadings. 23 items in rotated component matrix have loadings above 0.4 on their respective highest-loading factors, which suggests that each item is well represented by one of the extracted factors. This analysis indicates that the factor structure of 23-item instrument fit well within the TPACK framework's constructs.

Table 8 Re-run rotated component matrix results

	Component			
	1	2	3	4
TK1	-.008	.267	.753	.025
TK2	.065	.142	.774	.043
TK3	.164	.122	.689	.039
TK4	.007	.107	.817	-.005
TK5	.126	.048	.822	.052
TK6	-.005	-.022	.723	.001
CK1	.824	.113	.096	.086
CK2	.791	.186	.072	.007
CK3	.804	.052	.062	.054
CK4	.760	.077	.056	.077
CK5	.767	.084	.054	.008
CK6	.767	-.029	.007	.017
PK1	.115	.721	.106	.069
PK2	.116	.804	.065	.021
PK3	.063	.759	.110	.081
PK4	.073	.635	.118	.051

PK5	.020	.794	.088	-.011
PK6	.066	.840	.099	-.003
TPACK1	.042	.040	.086	.742
TPACK3	.090	.012	.002	.762
TPACK4	.019	-.034	.041	.802
TPACK6	.003	.149	-.025	.764
TPACK7	.056	.027	.022	.746

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity are tests to assess the suitability of data for factor analysis. Based on the results of the KMO measure and Bartlett's Test of Sphericity (Table 9), the data is very well suited for factor analysis. Generally, a KMO value greater than 0.6 is acceptable, while values above 0.8 are considered excellent (George & Mallery, 2003). The high KMO value indicates that the partial correlations among variables are appropriate for the analysis, and the significant Bartlett's Test indicates that the variables are sufficiently inter-correlated for factor analysis. These A value of 0.869 is considered very good. Bartlett's Test of Sphericity tests indicates that the correlation matrix is an identity matrix, meaning that the variables are unrelated and unsuitable for structure detection. The result of the test (significant at the 0.000 level) suggests that the variables are related, and the data is suitable for factor analysis (Field, 2013). Both tests collectively suggest that proceeding with factor analysis on the dataset is statistically valid.

Table 9 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.869
Bartlett's Test of Sphericity	Approx. Chi-Square	2616.884
	df	253
	Sig.	.000

Based on the above analysis in EFA, the adapted instrument with 23 items instrument fit well within the TPACK framework's constructs within the TPACK framework is a well-structured approach, and further CFA, SEM, and ANOVA analysis are based on the EFA results for the adapted 23-item instrument.

Descriptive statistics and scale reliabilities

Descriptive statistics (n=234) and scale reliability assessments are performed before conducting CFA. Conducting descriptive statistics analysis before helps in checking the quality of the data, ensuring that it is suitable for the CFA analysis (Field, 2013). Performing scale reliability before CFA provides evidence that the items within each construct are consistent and measure the construct effectively (DeVellis, 2016).

Table 10 presents summary statistics for the items associated with TK, PK, CK and TPACK. The means for all items are between 3.58 and 3.82, indicating a moderate to high level of agreement for the items. Standard Deviation (SD) values range from 0.952 to 1.126, indicating a moderate level of variability in responses. Skewness values (range of -0.563 to -0.957) are negative for all items, indicating a distribution that leans towards the higher end of the scale. Kurtosis values range from 2.785 to 4.000, which are mostly within the normal range but indicate some level of peak in the distribution. Overall, the descriptive data indicates a generally positive response towards all the items across TK, CK, PK, and TPACK.

Table 10 Descriptive statistics for TPACK, TK, CK, and PK survey items

Items	*Min*	*Max*	*M*	*SD*	*Skewness*	*Kurtosis*
TK1	1	5	3.679	1.017	-0.677	3.038

TK2	1	5	3.675	0.996	-0.594	2.998
TK3	1	5	3.722	1.038	-0.927	3.626
TK4	1	5	3.615	1.126	-0.831	3.085
TK5	1	5	3.744	0.96	-0.754	3.462
TK6	1	5	3.697	0.988	-0.729	3.397
CK1	1	5	3.675	1.043	-0.824	3.329
CK2	1	5	3.795	0.994	-0.816	3.466
CK3	1	5	3.701	0.996	-0.916	3.709
CK4	1	5	3.709	1.061	-0.957	3.616
CK5	1	5	3.709	1.028	-0.798	3.478
CK6	1	5	3.744	0.982	-0.86	3.637
PK1	1	5	3.774	0.956	-0.952	4
PK2	1	5	3.59	1.082	-0.824	3.188
PK3	1	5	3.735	1.039	-0.835	3.38
PK4	1	5	3.816	0.952	-0.824	3.689
PK5	1	5	3.752	1.068	-0.745	3.051
PK6	1	5	3.709	0.977	-0.806	3.567
TPACK1	1	5	3.692	1.023	-0.563	2.932
TPACK2	1	5	3.679	1.034	-0.568	2.862
TPACK3	1	5	3.662	1.077	-0.6	2.785
TPACK4	1	5	3.585	1.106	-0.618	2.812
TPACK5	1	5	3.65	1.047	-0.614	2.956

Table 11 is correlation matrix for all items with Pearson correlation coefficient values, which measures the strength and direction of the linear relationship between them. The coefficients range from +1 (perfect positive correlation) to -1 (perfect negative correlation), with 0 indicating no linear correlation. Values close to 0.3 or above suggest a moderate positive correlation (Cohen, 1988). For example, 0.297** between TPACK1 and TK1 means moderate correlation between these two items. TPACK items show varying degrees of correlation with TK, CK, and PK items,

which indicate that the TPACK construct is meant to represent a synthesis of technological, pedagogical, and content knowledge, so correlations are expected.

The significant correlations among TK, CK, PK, and TPACK items suggest that these constructs are related but distinct, which is consistent with the TPACK framework's view of these domains as overlapping yet separate areas of teacher knowledge (Mishra & Koehler, 2006).

Table 11 Correlation matrix for TPACK, TK, CK, and PK survey item

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
TK1	1																						
TK2	0.265**	1																					
TK3	0.216**	0.236**	1																				
TK4	0.293**	0.244**	0.228**	1																			
TK5	0.346**	0.290**	0.424**	0.381**	1																		
TK6	0.279**	0.309**	0.252**	0.327**	0.370**	1																	
CK1	0.201**	0.117	0.126	0.182**	0.247**	0.183**	1																
CK2	0.177**	0.257**	0.165*	0.155*	0.287**	0.181**	0.354**	1															
CK3	0.172**	0.135*	0.243**	0.165*	0.243**	0.178**	0.191**	0.267**	1														
CK4	0.232**	0.174**	0.184**	0.186**	0.243**	0.194**	0.221**	0.318**	0.279**	1													
CK5	0.247**	0.339**	0.222**	0.274**	0.216**	0.192**	0.312**	0.336**	0.367**	0.292**	1												
CK6	0.240**	0.160*	0.153*	0.194**	0.290**	0.194**	0.300**	0.276**	0.272**	0.237**	0.300**	1											
PK1	0.190**	0.238**	0.390**	0.170**	0.222**	0.236**	0.253**	0.217**	0.226**	0.239**	0.256**	0.208**	1										
PK2	0.227**	0.254**	0.131*	0.127	0.179**	0.156*	0.243**	0.257**	0.157*	0.187**	0.147*	0.252**	0.308**	1									
PK3	0.208**	0.157*	0.115	0.265**	0.108	0.273**	0.118	0.201**	0.139*	0.009	0.173**	0.030	0.203**	0.151*	1								
PK4	0.271**	0.217**	0.244**	0.142*	0.230**	0.196**	0.225**	0.187**	0.241**	0.295**	0.131**	0.110	0.393**	0.285**	0.276**	1							
PK5	0.160*	0.061	0.127	0.160*	0.147*	0.197**	0.124	0.122	0.124	0.209**	0.106	0.058	0.311**	0.250**	0.246**	0.327**	1						
PK6	0.087	0.114	0.149*	0.191**	0.245**	0.228**	0.080	0.177**	0.179**	0.171**	0.206**	0.110	0.219**	0.260**	0.194**	0.409**	0.235**	1					
TPACK1	0.297**	0.213**	0.239**	0.225**	0.252**	0.170**	0.236**	0.191**	0.175**	0.230**	0.257**	0.169**	0.279**	0.277**	0.141*	0.241**	0.256**	0.142*	1				

TP	**0.1**	**0.1**	**0.1**	**0.0**	**0.2**	**0.1**	**0.2**	**0.1**	**0.0**	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.2**	**0.4**	**1**			
AC	**51**	**82**	**93**	**96**	**28**	**69**	**41**	**99**	**86**	**20**	**35**	**43**	**74**	**12**	**32**	**28**	**77**	**05**	**75**				
K2	*	**	**		**	**	**	**		**	**	*	**	**	*	**	**	**	**				
TP	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.0**	**0.1**	**0.2**	**0.1**	**0.2**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.3**	**0.4**	**1**		
AC	**85**	**57**	**23**	**15**	**15**	**05**	**31**	**31**	**97**	**24**	**87**	**82**	**84**	**02**	**00**	**20**	**62**	**92**	**65**	**61**			
K3	**	*	**	**	**		*	*			**	**	**			**	*	**	**	**			
TP	**0.2**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.0**	**0.2**	**0.1**	**0.0**	**0.2**	**0.2**	**0.1**	**0.4**	**0.4**	**0.4**	**1**	
AC	**86**	**89**	**65**	**47**	**11**	**38**	**32**	**80**	**13**	**79**	**67**	**87**	**97**	**51**	**98**	**25**	**25**	**18**	**52**	**02**	**19**		
K4	**	**	*	**	**	**	*	**		**	**		**	*		**	**		**	**	**		
TP	**0.2**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.0**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**	**0.4**	**0.2**	**0.3**	**0.3**	**1**
AC	**04**	**74**	**83**	**49**	**26**	**45**	**43**	**66**	**68**	**44**	**48**	**21**	**21**	**72**	**73**	**62**	**64**	**35**	**20**	**92**	**44**	**67**	
K5	**	**	**	**	**	**	*	*		**	**		**	**	**	**	**	*	**	**	**	**	

** Correlation is significant at the 0.01 level(2-tailed)
* Correlation is significant at the 0.05 level(2-tailed)

4.1.2 TPACK measurement model

Two Confirmatory Factor Analysis (CFA) models are compared with a sample size of 234 to answer the first research question about the structure of a measurement model based on the TPACK framework. The comparison involves two different structural models:

Four-Dimensional Model represents TPACK as four correlated latent variables (TK with 6 items, PK with 6 items, CK with 6 items, and TPACK with 5 items).

Unidimensional Model represents all 23 items loading onto a single latent factor, suggesting a unidimensional structure for technology integration.

Four fit indices are used for model comparison. Comparative Fit Index (CFI) reflects the fit of the model relative to a null model. Values closer to 1 indicate a better fit. A CFI value equal to or greater than .90 is traditionally considered to indicate an acceptable fit to the data, while a value equal to or greater than .95 is indicative of a good fit (Bentler, 1990). Tucker-Lewis Index (TLI) is similar to CFI but penalizes model complexity. TLI values also range from 0 to 1, with higher values representing a better fitting model. TLI values of .90 or above are typically considered indicative of an adequate fit, whereas values of .95 or above suggest a good fit to the data. (Tucker &Lewis, 1973). Root Mean Square Error of Approximation (RMSEA) measures the amount of error per degree of freedom in the model. Values of RMSEA at or below .05 indicate a good fit, values up to .08 represent a reasonable fit, values between .08 and .10 reflect a mediocre fit, and values above .10 are indicative of a poor fit (Browne & Cudeck, 1992). Standard Root Mean

Residual (SRMR) measures the average discrepancy between the observed and predicted correlations. Values ≤ .05 are considered good (Hu & Bentler, 1999).

To test the Four-Dimensional Model, individual construct (TK, PK, CK and TPACK) are tested and interpreted separately.

Figure 7 shows a measurement model for TK, which is represented by six observed variables or items (TK1 to TK6). The numbers next to the arrows pointing from TK to each of the observed variables represent standardized factor loadings. These loadings range from .464 to .675, indicating varying degrees of association with the latent TK construct. Figure 8 displays a measurement model for the construct PK, which is operationalized through six observed indicators (PK1 to PK6). The standardized factor loadings range from .407 to .661. Figure 9 shows a measurement diagram for the latent variable CK, which is operationalized through six indicators (CK1 to CK6). The standardized factor loadings are from .500 to .628. Figure 10 displays a measurement model for the TPACK construct. Standardized factor loadings range from .570 to .703. Factor loadings of 0.4 or higher are generally considered meaningful or practically significant in social science research, especially within the context of factor analysis or structural equation modeling (Stevens, 2009). All factor loadings were significant, as indicated by a p-value of less than .001. In summary, these CFA model diagrams suggest they are valid measures.

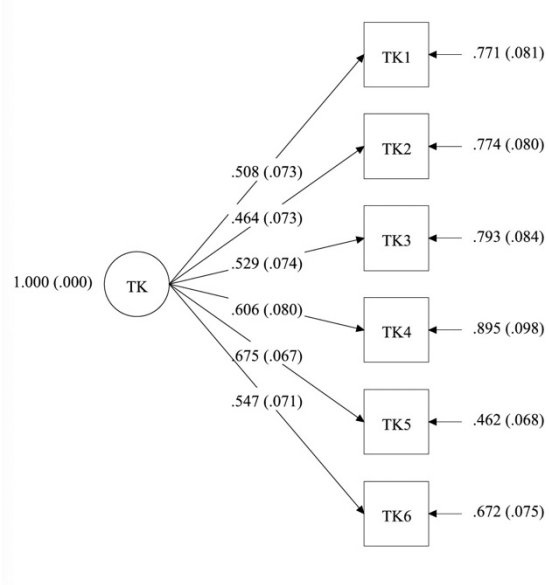

Figure 7 A measurement model for TK

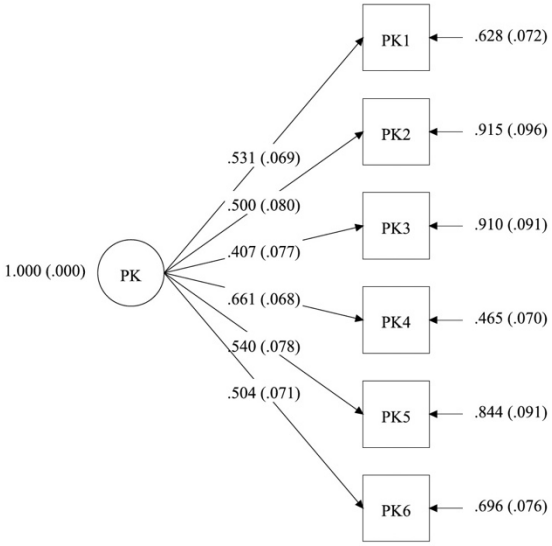

Figure 8 A measurement model for PK

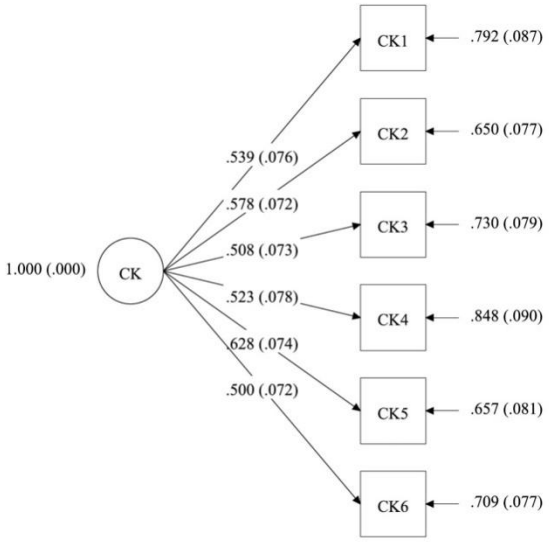

Figure 9 A measurement model for CK

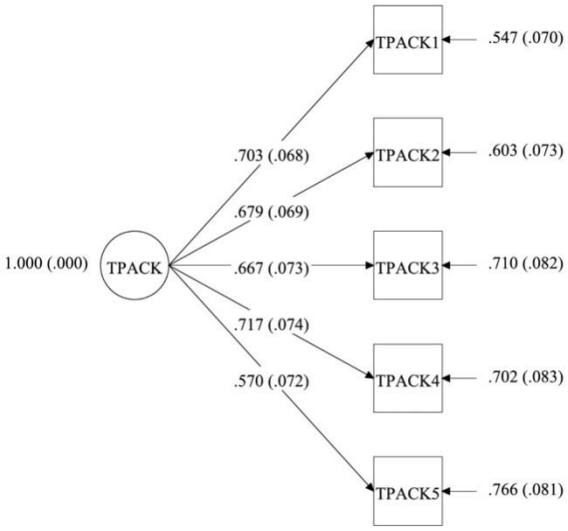

Figure 10 A measurement model for TPACK

The results (Table12) show the fit indices from CFAs of two different models assessed on a sample of 234 participants. These indices are used to determine how well the proposed model structures fit the observed data.

Table 12 Fit indices for comparative models in SEM

Indices	*χ2*	*df*	CFI	TLI	RMSEA	90%CI	SRMR
Four-factor model	260.172	224	.966	.962	.026	[.002 - .039]	.045
Unidimensional model	447.666	230	.797	.777	.064	[.055 - .072]	.064

In the four correlated factors model (Model 1), the χ^2/df ratio is approximately 1.16, which is good by conventual standards (Kline, 2015). The CFI is .966, which is close to 1, indicating a very good fit of the model to the data. The TLI is .962, also suggesting a good fit as it is above the threshold of .95 (Tucker &Lewis, 1973). The RMSEA is .026 with a 90% confidence interval ranging from .002 to .039. The SRMR is .045, which is below the .05 threshold, indicating a good fit.

In unidimensional model (Model 2), the chi-square to degrees of freedom ratio (χ^2/df) for Model 2 is approximately 1.95. This ratio is below the common acceptability threshold of 3:1, suggesting a poorer fit compared to Model 1 (Kline, 2015). The CFI has dropped to .797, which is below the .90 threshold for an acceptable fit, indicating a less satisfactory model fit compared to Model 1. The TLI is .777, which is also below the .90 threshold, further confirming a less satisfactory model fit.

By model comparison, Model 1 has significantly better fit indices across the board than Model 2. The results strongly favor Model 1, suggesting it is a better representation of the underlying data structure for the sample. Model 2 does not provide an adequate fit according to the traditional cutoff criteria for CFI and TLI, and while its RMSEA and SRMR are within reasonable ranges, they do not compare favorably to those of Model 1. Therefore, based on these results, four correlated factors model would be accepted as the better fitting model.

A four-factor correlated model is presented in Figure 11. This diagram consisted of four latent variables: TK, CK, PK), and TPACK. The standardized factor loadings, which represent the strength of the relationship between the latent variable and the indicator, ranges from .410 to .711. This model suggests that each set of observed variables is a good indicator of their respective latent construct, as evidenced by the significant factor loadings. The model also shows that the constructs are related to each other, which is consistent with the theoretical framework of TPACK that posits an interconnection among these domains of teacher knowledge.

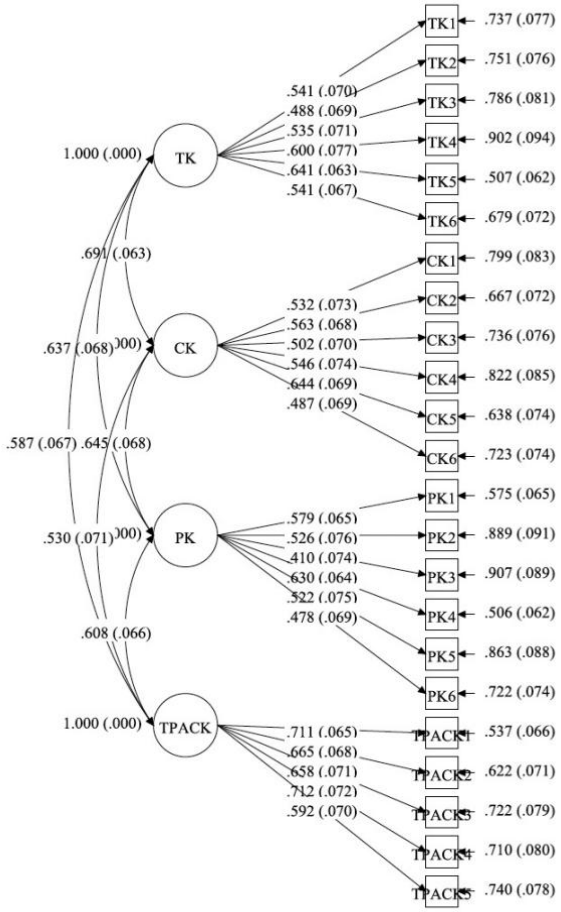

Figure 11 A four-factor correlated model of TPACK

Figure 12 presents the unidimensional measurement model with labeled "Tech_Int", which can be interpreted as "Technology Integration". The standardized factor loadings suggest that all indicators are significantly related to the Tech_Int construct, except factor loading for PK6, PK3

and CK6. Combined with the fit in Table 14, Four Factor related Model (Model) 1 is a better measurement model in this study.

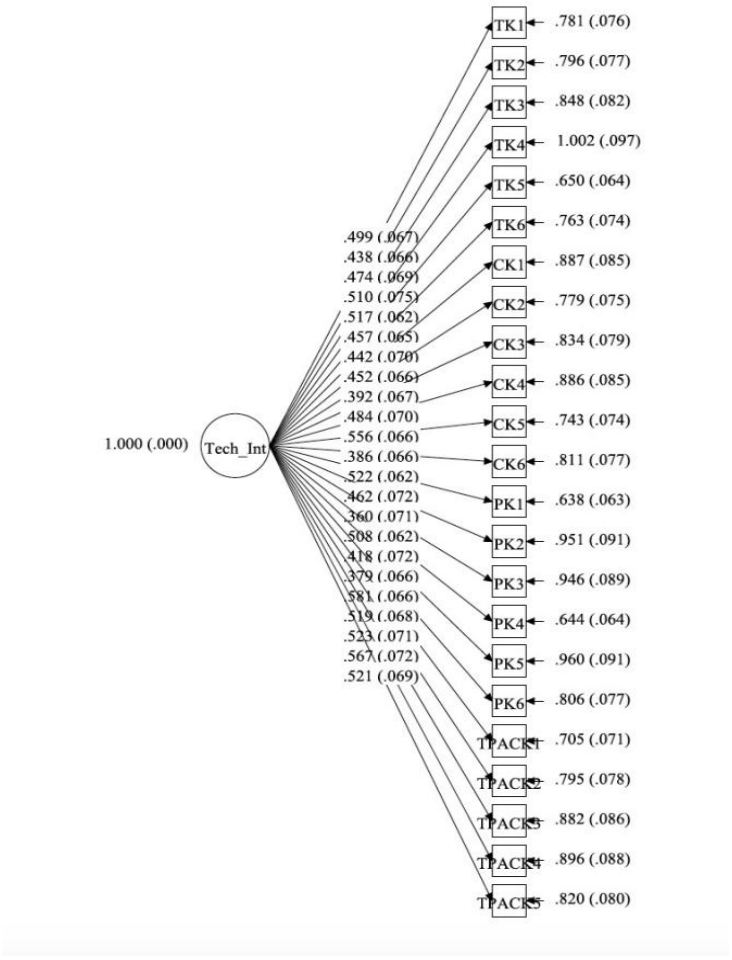

Figure 12 A unidimensional measurement model for TPACK

Overall, the model comparison indicates that Four Factor related Model is the preferred model based fit indices presented. The Four-Factor TPACK Measure Model is decided as the measurement model.

4.2 RQ2 result: correlations among TPACK domains

A SEM is conducted to explore the relationships between latent variables, including TK, CK, PK, and TPACK. The SEM model was performed by Mplus (Muthén & Muthén, 2006).

Estimation of model fit is indicated by the following fit indices in Table 13. RMSEA is .026. Values of RMSEA below .05 indicate a close fit of the model in relation to the degrees of freedom. CFI equals to .966, indicating a very good fit as values above .95 are generally considered indicative of a well-fitting model. TLI (.962) is also indicative of a good fit, with values above .95. SRMR is below the .05 threshold, indicating a good fit as well. Overall, the model demonstrated a good fit with the data as demonstrated.

Table 13 SEM fit indices for TPACK model

Indices	$\chi 2$	*df*	CFI	TLI	RMSEA	90%CI	SRMR
TPACK	260.172	224	.966	.962	.026	[.002 - .039]	.045

The factor loadings (see Figure 12), which are standardized, were all significant ($p < .001$), with the range of loadings for each construct (TK: .488 to .641, CK: .487 to .637, PK: .410 to .630, TPACK .592 to .712)

The path coefficients depicted in Figure 12 illustrate the direct influence of TK and PK on TPACK, and unstandardized coefficient is in Table 14. PK has a strong positive association with TPACK ($\beta = .443$, $p < .001$), meaning that as PK increases, TPACK also increases. TK also positively associated with TPACK ($\beta = .381$, $p < .01$), but the relationship is weaker compared to PK. However, CK was not a significant predictor of TPACK ($\beta = .129$, $p > .05$), suggesting that content knowledge alone does not have a significant impact on TPACK.

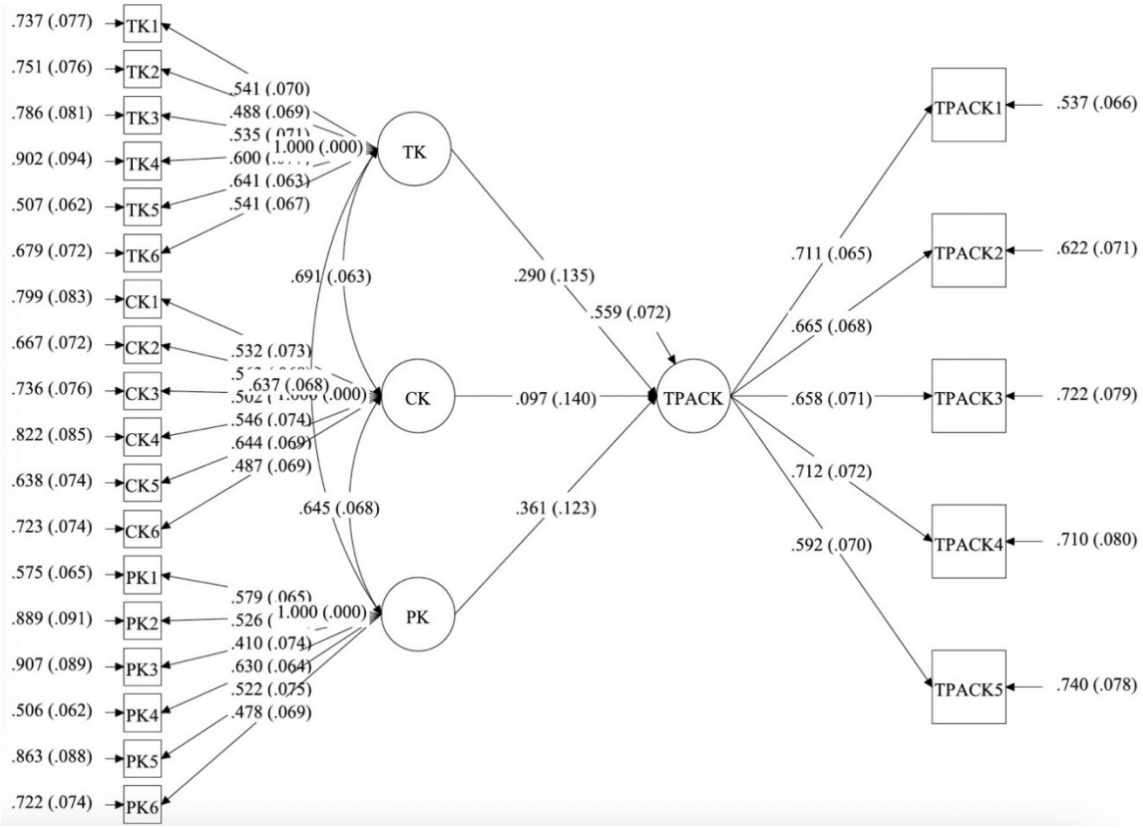

Figure 13 SEM results of hypothesized model

Table 14 Factor loadings and path coefficients for TPACK, TK, CK, and PK in SEM Analysis

		Estimate	S.E.	Est./S.E.	P(2-tailed)
TK	BY				
	TK1	1	0		
	TK2	0.902	0.163	5.541	0
	TK3	0.989	0.176	5.616	0
	TK4	1.11	0.189	5.871	0
	TK5	1.185	0.18	6.592	0
	TK6	1.001	0.169	5.928	0
CK	BY				
	CK1	1	0		
	CK2	1.058	0.178	5.953	0
	CK3	0.943	0.178	5.31	0
	CK4	1.027	0.189	5.431	0
	CK5	1.21	0.198	6.105	0
	CK6	0.916	0.168	5.463	0
PK	BY				
	PK1	1	0		
	PK2	0.908	0.155	5.842	0
	PK3	0.707	0.146	4.837	0
	PK4	1.087	0.154	7.079	0
	PK5	0.901	0.154	5.846	0
	PK6	0.825	0.146	5.631	0
TPACK	BY				
	TPACK1	1	0		
	TPACK2	0.935	0.114	8.216	0
	TPACK3	0.926	0.122	7.567	0
	TPACK4	1.002	0.123	8.166	0
	TPACK5	0.834	0.113	7.386	0
TPACK	ON				
	TK	0.381	0.184	2.07	0.038
	CK	0.129	0.188	0.687	0.492
	PK	0.443	0.161	2.744	0.006
TK	WITH				
	CK	0.199	0.044	4.533	0
	PK	0.199	0.043	4.605	0
CK	WITH				
	PK	0.199	0.044	4.541	0

In conclusion, the SEM analysis using Mplus software indicates that both PK and TK are important contributors to TPACK.

4.3 RQ3 results: changes in TPACK

Repeated Measure ANOVA is conducted on a sample of 167 participants. The paired-sample t-tests is conducted on pre- and post-surveys measure changes in TK, PK, CK and TPACK.

Table 15 is descriptive data for TK. The means (M) increased slightly from the pre-survey to the post-survey, indicating a positive change in TK over time. The standard deviations (SD) remain relatively consistent, showing stable variance across measurements.

Table 15 Pre-and post-survey mean scores and standard deviations for TK

	n	Pre-Survey		Post-Survey	
		M	SD	M	SD
S1	210	3.70	0.66	3.83	0.66
S1	186	3.75	0.65	3.97	0.62
S3	167	3.86	0.64	3.98	0.63

Table 16 displays the tests of within-subjects' effects for TK. The "Time" effect shows a significant increase in TK over time ($p < .001$), with a moderate effect size ($\eta 2 = .071$). The "Prepost" effect, which represents the overall change from pre- to post-survey, also shows a significant increase ($p < .001$) with a larger effect size ($\eta 2 = .215$), suggesting a substantial improvement in TK. The "Interaction" effect is not significant ($p = .062$), indicating that the change in TK was consistent across the different time points measured.

Table 16 Repeated measures ANOVA results for TK

	Source	Sum of Squares	df	Mean Square	F value	p-value	Partial Eta Squared (η^2)
Time		3.058	2	1.529	12.765	.000	.071
Prepost	Sphericity	6.441	1	6.441	45.595	.000	.215
Intaction	Assumed	.727	2	.363	2.808	.062	.017
Error(time)		42.968	332	.129			

Table 17 is the descriptive statistics, which shows a slight increase in PK from pre- to post-survey.

Table 17 Pre- and post-survey mean scores and standard deviations (SD) for PK

	n	Pre-Survey		Post-Survey	
		M	SD	M	SD
S1	210	3.71	0.66	3.85	0.63
S2	186	3.62	0.66	3.82	0.63
S3	167	3.64	0.67	3.84	0.64

Table 18 depicts the within-subjects' effects, which indicate a significant increase in PK over time, with an effect size of $\eta 2 = .271$ for the "Prepost" effect, indicating a substantial improvement.

Table 18 Repeated measures ANOVA results for PK

	Source	Sum of Squares	df	Mean Square	F	p-value	Partial Eta Squared (η^2)
Time		.752	2	.376	3.782	.024	.022
Prepost	Sphericity	7.787	1	7.787	61.638	.000	.271
Intaction	Assumed	.272	2	.136	1.307	.272	.008
Error(time)		34.580	332	.104			

Table 19 and Table 20 are Descriptive Data and Effects for CK. CK also shows a positive change from pre- to post-survey, with consistent SDs. The "Prepost" effect for CK is significant with a very large effect size (η2 = .286), indicating a significant increase in CK over time.

Table 19 Pre- and post-survey mean scores and standard deviations (SD) for CK

	n	Pre-Survey		Post-Survey	
		M	SD	M	SD
S1	210	3.70	0.63	3.88	0.62
S2	186	3.68	0.73	3.83	0.65
S3	167	3.81	0.62	3.98	0.57

Table 20 Repeated measures ANOVA results for CK

	Source	Sum of Squares	df	Mean Square	F	p-value	Partial Eta Squared (η^2)
Time		3.663	2	1.832	16.067	.000	.088
Prepost	Sphericity	7.994	1	7.994	66.441	.000	.286
Intaction	Assumed	.121	2	.061	.483	.617	.003
Error(time)		41.647	332	.125			

Table 21 and Table 22 are descriptive data and effects for TPACK. TPACK scores increased from pre-survey to post-survey. The "Time" effect is significant ($p < .001$) with a moderate effect size (η2 = .056), and the "Prepost" effect is also significant ($p < .001$) with a large effect size (η2 = .214), indicating a substantial improvement in TPACK over time.

Table 21 Pre- and post-survey mean scores and standard deviations (SD) for TPACK

	n	Pre-Survey		Post-Survey	
		M	SD	M	SD
S1	210	3.65	0.75	3.87	0.68
S2	186	3.70	0.69	3.86	0.72
S3	167	3.81	0.73	3.94	0.66

Table 22 Repeated measures ANOVA results for TPACK

	Source	Sum of Squares	df	Mean Square	F	p-value	Partial Eta Squared (η^2)
Time		2.859	2	1.430	9.864	.000	.056
Prepost	Sphericity	6.645	1	6.645	45.170	.000	.214
Intaction	Assumed	.253	2	.127	.967	.381	.006
Error(time)		43.440	332	.131			

For all areas (TK, PK, CK, and TPACK), there is a significant increase in scores from the pre- to post-survey, suggesting that the intervention or educational program had a positive effect on participants' knowledge in these areas. The large effect sizes for the "Prepost" effects indicate that these are meaningful changes. The significant interaction effects suggests that these improvements were consistent across time intervals within the study.

In summary, the educational program or intervention appears to have been effective in increasing participants' self-efficacy across all measured domains, with the changes being both statistically significant and educationally meaningful.

5. Results of Study 2 (RQ2)

5.1 RQ1: Changes within TPACK domains

Based on the analysis of the observation and interview data, these three technology-using participants were found to exhibit all four TPACK knowledge domains in their online teaching with the highest percentage recorded as TPACK. And 389 TPACK were coded under segments were identified as a result of observing these three instructors while teaching in classroom. Figure 14 shows the TPACK progress of Lily, Tom and Lucy in three consecutive semesters. It indicates that all three individuals show progress in TK over time. While PK sees variable trends but with significant growth for Lucy in the third semester. Tom and Lucy peak in CK in the second semester before declining. TPACK growth is observed for Lily and Tom, while Lucy shows a decline over the semesters. In all, the trends suggest that the focus or success in different knowledge areas changed over time for individual.

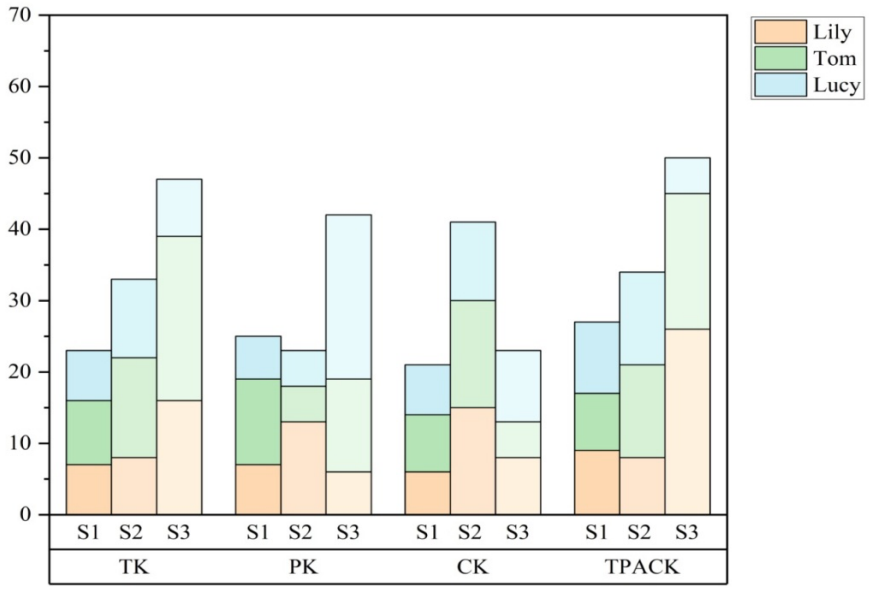

Figure 14 An overview of individual TPACK development

Table 23 examines changes in Lily's TPACK over three semesters (S1, S2, S3). TK shows an increase over the semesters, from 7 in S1 to 16 in S3. This suggests that Lily's technological knowledge improved significantly over time. There is a fluctuation PK domain, with an initial value of 7 in S1, increasing to 13 in S2, but then decreasing to 6 in S3. The CK domain also shows growth, starting at 6 in S1 and increasing to 15 in S2, then slightly decreasing to 8 in S3. And the overall TPACK score starts at 9, drops to 8 in S2, but then sees a substantial increase to 26 in S3. The total row sums up the scores across all semesters, with the highest total score being in the TK domain (31), followed by CK (29), and then PK (26). The total TPACK score is 43. The Chi-square value reported is 16.0465, with a p-value less than 0.05. The p-value indicates that there is a statistically significant change in Lily's TPACK and its domains across the semesters.

From the data results, it can be concluded that Lily's TK has consistently increased, which could be due to increased exposure to technology, more practice, or targeted professional development. Her PK has increased in the second semester but then dropped in the third semester. This might indicate that while Lily was gaining some pedagogical skills, there might have been factors in the third semester that affected her pedagogical development. Her CK increased significantly in the second semester, perhaps due to a focus on content-specific training or experiences, but the decrease in the third semester may suggest a shift in focus or perhaps challenges in maintaining content knowledge growth. The overall TPACK score improved significantly by the third semester, indicating that despite fluctuations in PK and CK, Lily's ability to integrate these domains with technology has improved.

Table 23 Lily's TPACK and its domain changes

Semester	TK	PK	CK	TPACK
S1	7	7	6	9
S2	8	13	15	8
S3	16	6	8	26
Total	31	26	29	43
Chi- square: 16.046				p<.05

Table 24 shows Tom's changes within TPACK domains over three semesters (S1, S2, S3). Tom's TK scores increased from 9 in S1 to 23 in S3, indicating substantial growth in this domain over time. His PK scores started at 12 in S1, dropped to 5 in S2, but increased to 13 by S3. This suggests variability in Tom's pedagogical development. Tom's CK scores show an interesting pattern, starting at 8 in S1, peaking at 15 in S2, and then dropping back to 5 in S3. His overall TPACK score begins at 8, increases to 13 in S2, and then rises more sharply to 19 in S3. The total scores across all semesters are highest for TK (46), followed by PK (30), and then CK (28). The total TPACK score is 40. The Chi-square value is 4.7523 with a p-value less than 0.05, which indicates there is a statistically significant change in Tom's TPACK and its domains across the semesters.

Tom's TK has shown consistent improvement. This could be the result of ongoing learning, training, or increased engagement with technology. His PK has fluctuated, with a significant dip in S2. CK peaked in the second semester but then declined to its original level in S3. It could be speculated that Tom may have been focusing on a particular content area in S2, which was not maintained or emphasized in S3. The overall TPACK score increased with time, suggesting that

despite the ups and downs in PK and CK, Tom's ability to integrate technology, pedagogy, and content knowledge has improved. The chi-square test result suggests that the changes observed across the semesters are not due to random chance and that there is a significant difference in at least one of the domains across the three semesters.

Table 24 Tom's changes within TPACK domain

Semester	TK	PK	CK	TPACK
S1	9	12	8	8
S2	14	5	15	13
S3	23	13	5	19
Total	46	30	28	40
Chi- square: 4.7523			$p<.05$	

Table 25 displays Lucy's changes within the TPACK domains over three semesters (S1, S2, S3).

Lucy's scores in TK area show a slight increase from S1 to S2, but then a decrease in S3. The overall trend suggests some improvement in technology use, but with a dip in the final semester. Her fluctuation in TK scores could be due to various factors, including changes in technology access or usage patterns. The decline in the last semester might point to specific challenges or a shift in focus.

There is a significant jump in Lucy's PK score from S2 to S3, indicating substantial growth or a focus on pedagogical development in the last semester. The dramatic increase in PK during S3 is striking and would suggest that this was an area of intense development or focus during that semester.

Her CK scores have increased slightly in S2 and remained stable in S3, indicating a steady enhancement in her understanding or application of the content. CK change shows moderate growth and stability, which is often desirable as it indicates a consistent approach to content-related knowledge and skills.

Her overall TPACK score began at 10, increased to 13, but then dropped to 5 by S3. This drop is notable and might suggest a challenge in integrating all three domains effectively by the final semester. The overall TPACK score's sharp decrease in S3 is counterintuitive, considering the rise in PK. This suggests that while Lucy's pedagogical skills improved, the integration of these with technological and content knowledge may have been less successful.

The Chi-square value given is 18.3221 with a p-value less than 0.05. This result suggests that there is a statistically significant change in Lucy's TPACK and its domains across the semesters. The data suggests that while Lucy made significant strides in pedagogical development, however, it may not have translated into an improved combined TPACK score.

Table 25 Lucy's changes in TPACK and its domains

Semester	TK	PK	CK	TPACK
S1	7	6	7	10
S2	11	5	11	13
S3	8	23	10	5
Total	26	34	28	28
Chi- square: 18.3221			p<.05	

Table 26-29 provide a comparison of Lily's, Tom's, and Lucy's scores in the TPACK domains across three semesters (S1, S2, S3), as well as their total scores and a Chi-square test result for each domain.

All participants showed an increase in TK over the semesters, with Tom showing the largest overall growth. The Chi-square test for TK is 3.36651 with a p-value less than 0.05, indicating a statistically significant difference in TK scores over time for at least one of the participants.

Lily and Lucy show an increase in PK over time, with Lucy showing a substantial increase in S3. Tom's PK decreased in S2 but improved in S3. The Chi-square test for PK is 17.8281 with a p-value less than 0.05, suggesting a statistically significant difference in PK scores over time for at least one of the participants.

Lily's CK peaked in S2 and then decreased. Tom's CK showed a steady increase from S1 to S2 and then a decline in S3. Lucy's CK remained the same from S2 to S3 after an initial increase. The Chi-square test for CK is 2.71745 with a p-value higher than 0.05, indicating no statistically significant difference in CK scores over time.

Lily's TPACK score increased substantially from S1 to S2 but decreased in S3. Tom's TPACK score consistently increased. Lucy's TPACK score increased from S1 to S2 but then significantly decreased in S3. The Chi-square test for TPACK scores is 13.2799 with a p-value less than 0.05, suggesting a statistically significant difference in TPACK scores over time for at least one of the participants.

In summary, all participants improved in TK over the semesters. PK and TPACK scores also showed significant changes over time, while CK did not. This could indicate that while technological skills improved across the board, the ability to integrate pedagogical and content knowledge with technology (as reflected in the TPACK scores) varied more significantly among

the individuals, with Lucy showing the most variance. The lack of significance in CK changes suggests that content knowledge remained relatively stable across semesters compared to the other domains.

Table 26 TK changes over three semesters

TK	Lily	Tom	Lucy
S1	7	9	7
S2	8	14	11
S3	16	23	8
Total	31	46	26
Chi- square: 18.3221		p<.05	

Table 27 PK changes over three semesters

PK	Lily	Tom	Lucy
S1	7	12	6
S2	13	5	5
S3	6	13	23
Total	26	30	34
Chi-square：17.8281		p<.05	

Table 28 CK changes over three semesters

CK	Lily	Tom	Lucy
S1	6	8	7
S2	15	15	11
S3	8	5	10
Total	29	28	28
Chi-square= 2.71745		p>.05	

Table 29 TPACK changes over three semesters

TPACK	Lily	Tom	Lucy
S1	9	8	10
S2	8	13	13
S3	26	19	5
Total	43	40	28
Chi-square= 13.2799		p<.05	

5.2 RQ2: OTL within TPACK domains

The results reveal opportunities in the teaching practices and university contexts to support the development of the teachers' TPACK. Most of these opportunities occurred during the CPD program. Thematic diagrams offer a comprehensive visualization of the varying opportunities for professional development encountered by instructors across different knowledge domains within the field of CPD program, teaching practice and university context. These figures graphically represent the opportunities available for each specific educational experience.

While TPACK remains the cornerstone of these programs, TK also receives substantial attention. Here, the emphasis is on the mastery of digital tools and resources that support language teaching and learning (Koehler & Mishra, 2005). The development of PK, specifically delivering strategies of linguistic concepts and language acquisition practices, is also a significant component of such CPD programs, as highlighted by Ball and colleagues (2008). However, as noted by Archambault and Barnett (2010), the integration of language content and language skills of language skills do not seem to receive the same level of support within the CPD framework, which representing CK.

The symbiotic relationship between PK and TK is pivotal; when language instructors adopt pedagogical strategies informed by technology, they concurrently solidify their command over both pedagogical approaches and the technological resources they employ. This dual development is critical in promoting a comprehensive educational approach where technology and pedagogy coalesce to enhance language learning.

The following discussion explores the specific variations observed within each sub-domain of Technological Pedagogical Content Knowledge (TPACK), Technological Knowledge (TK), Content Knowledge (CK), and Pedagogical Knowledge (PK) for language instructors in these transnational contexts.

5.2.1 Opportunities supporting TK, PK, CK and TPACK in CPD programs

When conducting a thematic analysis on TPACK development opportunities within CPD programs, four themes that are explored:

Digital Literacy and Technology Mastery

This theme explores how CPD programs help educators to not just use technology but to integrate it seamlessly with pedagogical strategies and content knowledge. It includes discussions on specific teaching tools, software, or platforms and how these can be used to enhance language teaching.

This verifies substantial opportunities to learn about new tools, platforms, and digital resources. These new tools, platforms and digital resources were instrumental in aiding TNHE language instructors to grasp specific teaching objectives, which were often directly tied to distinct assignments, classroom activities, or pedagogical tasks. Through learning these digital tools and resources, language instructors can enrich the learning experience, making it more effective, efficient, and aligned with the needs of TNHE students during COVID-19. For instance, in a CPD

course of Technological Tools, opportunities to deepen instructors' core technological knowledge in language teaching focus on understanding of virtual classroom platforms like Zoom, the enhancement of technological skills was typically linked to the execution of specific CPD courses. Such as exploring nuances verifies in the dialogue in interviews. "Breakout room feature enables me to divide the main meeting into smaller groups for collaborative activities or discussions, this is really important in my group discussion. Previously, I only know opening rooms and closing breakout rooms. However, as a host, I do not know how to manage rooms. By this course, I can jump between breakout rooms to monitor and participate in discussions. I can also send messages to all breakout rooms for announcements or updates".

Courses in CPD also updates instructors' previous TK knowledge. "Blackboard is the LMS we used before pandemic. We can upload the learning material, start forum and interact with students under some threads. We also do the evaluation on Blackboard. It is very interesting that Zoom can be integrated with Blackboard, which I learned from CPD program, this allows me for seamless access and management within the existing digital learning infrastructure".

Peer Learning and Transnational Cooperation

TNHE CPD programs are designed with a global perspective, addressing cross-cultural communication, which emphasizes collaborative approaches to professional learning. This theme can explore how sharing experiences and strategies among TNHE teachers supports the development of TPACK, with a focus on peer learning, mentoring, and community of practice models.

The coding phase "collaborative learning" distills further how these experiences bolstered the instructors' competencies in teaching, understanding student needs, and curriculum adaptation during the pandemic. For example, instructors learned how to facilitate group projects and

discussions by encouraging peer-to-peer learning and collaboration from Microsoft Teams (PPT slides from CPD). This coded theme yielded deeper insights into how the instructors PK was being shaped and highlighted areas where additional support might be necessary.

Instructional Design and Curriculum Development

A key aspect of TPACK is the ability to design or adapt curriculum and instruction that leverages technology. This theme could explore the ways CPD programs address curriculum design principles that integrate TPACK concepts. PK is developed through opportunities that include practice teaching, workshop etc. These opportunities allow teachers to refine their instructional strategies and understand student learning processes.

Adapting face-to-face teaching strategies to an online format have provided teachers with opportunities to develop new pedagogical approaches. This includes managing virtual classrooms, fostering online discussions, and engaging students who might be facing various challenges due to the pandemic. For example, participant 2 engaged in reflective practice through inquiry-based assessments. According to interview responses, this practice aids in the identification of educational deficiencies that may exist among students, as well as gaps in his personal content understanding. Classroom observations can corroborate this, revealing how such reflective assessments lead to targeted research and meticulous lesson preparation. This strategy is indicative of an opportunity for pedagogical goals (inquiry-based learning).

TPACK Enablers and Barriers

It's important for TNHE CPD programs to consider the factors that facilitate the development of TPACK among educators. Different from traditional CPD programs, TNHE CPD programs are typically more focused on addressing the unique challenges and opportunities of transnational education, such as language barriers and the integration of technology across borders.

This theme could examine access to resources and personal attitudes towards technology that affect TPACK development.

TPACK have more learning opportunities compared to other domains during the CPD programs. Participants engaged in activities designed to integrate technology, pedagogy, and content knowledge, observing and reflecting on how these elements work together effectively in a classroom setting. In the context of CPD programs aimed at language instructors within transnational education settings, there is a pronounced focus on fostering TPACK. Such programs are inherently designed to endow educators with the expertise necessary to leverage technological tools to enhance language instruction, affirming the pedagogical tenets set forth by Mishra and Koehler (2006). TPACK, originally conceptualized by Shulman (1986) and expanded upon by Mishra and Koehler, is integral in guiding instructors to deliver language content effectively, considering students' backgrounds and ensuring alignment with educational standards. This also echoes with the evidence from observations from CPD course, teaching plan and PPT slides.

In summary, during the COVID-19 era, language instructors in transnational contexts were supported by TPACK-oriented CPD programs to cultivate a multifaceted understanding of technological integration (TK) and effective pedagogical methods (PK), all essential for navigating the complexities of language instruction in an unprecedented global educational landscape.

From few themes related to teaching content, it can be concluded that CK has the least learning opportunities in a CPD course. Though CK is an essential element of TPACK, a CPD course focused on TPACK may not necessarily provide new content knowledge specific to teachers' subject areas. Instead, it would focus more on how to teach that content using technology (TK) and effective pedagogical approaches (PK). Course observations, PPT slides, and lesson plans would likely not be aimed at expanding instructors' knowledge in their specific language

areas. Instead, CK would be addressed in terms of how to deliver and contextualize content using technology and pedagogical strategies. CPD during COVID-19 often focuses on pedagogical methods and technology integration (TK and PK), as these are areas of rapid change and require ongoing professional development, as disclaimed in CPD lesson plan.

5.2.2 Opportunities supporting TK, PK, CK and TPACK in teaching practices

Thematic analysis of TPACK development opportunities during teaching practice could yield only two themes.

Collaborative Learning and Peer Support

This theme explores how collaboration among transnational instructors enhances their TPACK. It includes peer mentoring, shared learning experiences, and collaborative development of teaching strategies, emphasizing the importance of community in professional growth.

Collaboration with international colleagues allows instructors to exchange diverse pedagogical methods and strategies, which is also a learning opportunity in PK. This cross-cultural professional development can lead to the adaptation of new teaching approaches that may not have been considered within one's own educational context. For example, Participant 3 said his British colleague introduced him to the concept of "shadowing". "Inspired by our collaboration in Group E13 teaching, I started incorporating shadowing exercises into my online sessions. For instance, I played audio clips from native speakers, and students would 'shadow' the speech. It turned out to be a fantastic way for students to practice intonation and rhythm."

Feedback Mechanism and Reflective Practices

Investigating how feedback from students and colleagues, as well as self-reflection practices, contribute to the development of TPACK. This theme emphasizes the importance of reflective

teaching practices and feedback in continually improving and adapting teaching methods and technology integration.

Effective online or hybrid teaching requires the thoughtful integration of technology with pedagogy and content. Teachers would likely discuss their experiences and challenges in adapting to this new way of teaching, reflecting significant learning in TPACK as they worked to maintain educational quality in a virtual environment. Through structured interviews with educators and systematic classroom observations, insights into the learning opportunities in TPACK development can be gleaned. For instance, Interviewee 1 examined curricular standards to inform her selection and utilization of digital resources, thereby enhancing her linguistic teaching proficiency. This approach demonstrates an application of TPACK, as it involves the alignment of content (linguistics), pedagogy (teaching strategies), and technology (digital resources). The application of these insights into teaching practices can be observed when instructors leverage technology to conduct assessments that not only measure student understanding but also provide immediate feedback for instructional adaptation. For example, the use of online quizzes with real-time data analysis tools helped teachers like Participant 2 identify misconceptions or areas that require additional instruction (observation data), which is a practical application of TK. Furthermore, teachers can utilize this data to refine their instructional strategies (PK) and content delivery (CK), thereby optimizing the TPACK framework in their teaching practices.

5.2.3 Opportunities supporting TK, PK, CK and TPACK in university context

Advanced Professional Development Support

This theme focuses on the benefits of fund among university faculty. It encourages updating content knowledge and teaching methodologies, thereby enhancing CK, PK, and TPACK.

Different from previous study (Herring et al., 2016), this theme indicates that ongoing, specialized training is crucial for educators to keep pace with rapid technological changes, suggesting a shift from one-time workshops to continuous learning paths. For example, opportunities for the development of CK in language were somewhat limited in university context, but "Faculty Development Fund" that sponsors advanced research and study in their subject knowledge field was granted each semester, to engaging instructors in innovative pedagogical practices continuously. For example, the importance of critical thinking in academic writing was highlighted in sub-research domain of writing research with 4 consecutive semesters, where instructors updated their content knowledge in ability to construct a coherent argument and to reason logically served as an opportunity for them to support their core content knowledge so they could later evaluate students' reasoning in academic writing. However, interviews with administrators also confirm the limited opportunities university providing for CK development. As Administrator 1 said "Administrators need to not only provide resources but also create a culture that values deep scholarly inquiry. We encourage interdisciplinary collaboration, where faculty can expand their CK by learning from colleagues in related fields, which also fosters a richer educational environment for our students." This means administrators will not play in directly supporting CK development.

During pandemic, the educational affair department provide funds for course development specifically designed to integrate technology with content and pedagogy provide direct TPACK development opportunities. For instance, Instructor 3 said she had applied for a course reform fund. With the fund from the university, she designed an academic writing course which involves a digital curriculum unit that incorporates questionnaire design (CK) with Questionnaire Star App (TK) and data-driven learning pedagogy (PK). The university also engage instructors in

opportunities that specifically target TPACK domain, then instructors can enhance their ability to design and implement effective and innovative teaching practices that utilize technology to its fullest potential while maintaining pedagogical soundness and content accuracy. For example, Administrator 3 said "The university has also collaborated with technology companies to provide faculty with access to cutting-edge educational tools. For example, we have a partnership with Intelligence Star Company that provides virtual reality tools for creating immersive learning experiences. As technology continues to evolve, it's crucial for us to prepare instructors for the technological landscape they encounter in their professional lives. Intelligence Star Company give lectures on how to use the digital platform, as well as how to teach English with some specific functions." This suggests there is explicit and targeted opportunities within university context that would aid instructors in fostering equitable language teaching practices, taking into account the full spectrum of student diversity and its impact on language education during the challenges of the pandemic.

Faculty Mentoring and Support Systems

Compare with previous findings (Hofer et al., 2016), this theme highlights the importance of collaborative networks and mentorship in fostering innovation and confidence in using TPACK, showing a move from isolated to communal growth strategies. "University organized periodic workshops among instructors in China and around the world, which typically designed to be interactive sessions where educators can learn about and practice new teaching methodologies in line with the online teaching The collaborative nature of these workshops encourages the sharing of ideas and experiences. Teachers learn from one another's successes and challenges." (Administrator 1) "College also organized peer observations. Because two teachers collaboratively teach for one class, one is responsible for reading and writing, and the other is responsible for

listening and speaking. The peer observation enables me to see firsthand how theoretical pedagogical concepts are applied in practice. By observing my peer teaching in the virtual classroom, I can gain insights into student engagement, classroom management, and the implementation of learning activities" (Instructor 1). Thus, pedagogy workshops and classroom observations allow teachers to exchange effective teaching strategies, explore new classroom management techniques, and adapt general pedagogical methods to diverse classroom settings (Shulman, 1986).

Technology-Enhanced Learning Environments

It's important to consider the factors that facilitate the development of TPACK within university context. This theme examines new insights could demonstrate the growing sophistication of technological tools and platforms, emphasizing the need for environments that are adaptable, student-centered, and integrated with pedagogical goals. Universities that invest in technological infrastructure, continuous professional development, and encourage collaborative practices typically foster better TPACK integration among teachers. Conversely, institutions with limited support or restrictive policies might impede this growth. Examining these differences can provide insights into how tailored supports and policies can enhance TPACK-based teaching and learning in various educational contexts.

As Administrator 3 said "Universities have invested significantly in digital infrastructure, which would naturally lead to a focus on TK as they aim to maximize the return on these investments by equipping faculty with the necessary skills to use new technologies, for example the virtual classroom software like Zoom, Moodle, and various other digital tools to engage with students, assess learning, and manage courses online." Such investment also echoes reaction from instructors, which can be demonstrated by Lily's abrupt increase in TK and TPACK in Semester

3. With Administrator 3's policies, regular TPACK workshops enable teachers to integrate technology more effectively in their language teaching, leading to innovative practices and improved student engagement.

In contrast, a university without such policies might see slower adoption of technology-enhanced teaching methods, potentially affecting the quality of education and student outcomes. The differences in policies and supports directly impact the development and application of TPACK among educators. For example, Lucy who performs not that well in TK and TPAKC in S3 said "It was daunting. Unlike face-to-face teaching, where you have immediate feedback from students, online teaching felt like talking into the void. But I think my university has not invested that much in Zoom software. I found that hybrid mode of delivery actually hard to achieve sometimes, and this impedes student participation."

TK is the pivot to remote teaching necessitated a rapid upskilling in technology use, which means the practical teaching experiences during COVID-19 further honed the instructors' technological knowledge in language teaching, typically aligned with the curriculum standards, lesson planning, or in response to students' preconceived notions or misconceptions.

PK received moderate support opportunities, specifically on eliciting students' ideas and understanding them as inquisitive learners of the world around them.

In the context of TPACK, opportunities for learning are essential and most for the development of comprehensive knowledge required by teachers, particularly in teaching science. This approach aligns with TPACK by emphasizing the integration of technology (TK), pedagogy (PK), and content (CK) in teacher education. The results highlight how practice-based teacher education programs---CPD programs provide experiential learning opportunities that reflect real classroom teaching experiences. These programs, grounded in TPACK principles, foster a deep

understanding of how technology can be effectively integrated with pedagogical strategies and subject content.

Regarding CK development, the results suggests that while this is important, it often receives less emphasis compared to the other knowledge domains in CPD programs, university contexts and teaching experience. Teachers develop CK through their subject-specific education, but this is often viewed as just one component of a broader educational framework. In the TPACK context, while CK is fundamental, it is the integration of this knowledge with PK and TK that creates a more effective teaching approach.

Finally, TK is given significant attention in university contexts, reflecting the increasing importance of technology in education. Opportunities for learning in university contexts, CPD programs and teaching experiences often include the use of educational technologies, highlighting the need for teachers to be proficient in various technological tools and platforms. This focus on TK is crucial for teachers to effectively integrate technology into their teaching practices, which is a core component of the TPACK framework.

In summary, CPD programs, teaching practice and university contexts would have afforded teachers the most learning opportunities in the areas of TK and TPACK, as these were most directly impacted by the transition to remote teaching. Meanwhile, PK would be adapted to new formats, and CK would likely remain a constant, with less emphasis on expanding this area compared to the others.

5.3 RQ3: OTL related to TPACK expertise in teaching practice

5.3.1 Lily's trajectory of TPACK and opportunities to learn

Trajectory of TPACK and OTL

CK development. Lily's expertise in language content (CK) is evident in her ability to guide students through writing a presentation script. She began the discussion by asking: "How to write an introduction paragraph for your presentation?" (class observation). Following a student's initial response, the instructor encouraged further discussion by inquiring, "Can you describe the format of an introductory paragraph?" A student provided an answer, and Lily reiterated that the structure for a presentation script differed from that of a research essay. She then said, "the main points or sections must be included in your introduction" and a short discussion about the main points writing. Then the class developed into discussion for main point presenting practice. So, she understood how to the start the speech by engaging audience and setting the stage for main content in presentation. However, the content knowledge she taught in this period did not relate to her experiences within CPD programs or university context.

PK development. Instructors also employ various pedagogical strategies (PK) to facilitate teaching. Some of these pedagogies are from her peer colleague. Collaboration among instructors from different countries enhanced teaching methodologies, the value of integrating diverse pedagogical approaches, and the benefits of such integration for creating a well-rounded and effective learning environment. For example, Instructor 1 taught E11 Academic Speaking and Listening, and her peer taught E11 Academic Reading and Writing. She said:

"We shared our teaching methods and strategies. I realized that since we teach the same group, we decided to work together to see if we could create a more cohesive teaching method for our students. I am very fascinated by her differentiated instruction method, recognizing that

students have varying backgrounds, learning styles, and proficiencies, this approach involves providing different students with different ways of learning the same material. So, I incorporated her differentiated approaches into my speaking and listening classes."

This collaboration in pedagogy exemplifies a multifaceted pedagogical methodology, enriching her strong foundation in Pedagogical Knowledge (PK). This collaboration highlights a strategic pedagogical development, facilitating a more comprehensive and cohesive learning experience for students. Such an exchange of teaching practices between instructors underscores the value of peer collaboration in the continuous refinement and enhancement of instructional techniques. This collaborative approach not only diversifies the range of pedagogical strategies employed but also fosters a more integrated and holistic academic environment, thereby enriching the educational experience for students in both areas of study.

TK development. The use of videoconference tools for delivering and class management implies the incorporation of technology (TK) into her teaching. This involves using software for videoconference tools for delivering and class management, reflecting an understanding of how technology can enhance language teaching. For instance, she expressed,

"I have a sense of ease because I'm not fearful of unfamiliar digital tools if I encounter them. In the CPD program, there are two courses aiming to teach digital tools. Previously, I always feel confused even I had this kind of course. However, the online CPD gives more practice scenario for new digital tool utilization in teaching practice. For example, there is a mock test for Teams using. Any questions left can be tackled by the tutors from CPD program. They are eager to help me. And I really feel confident after I finished those two classes. And I do feel very confident in my technological ability than before." (quotes from CPD interview)

Her participation in the CPD courses shows her continuous effort to build her TK knowledge and ongoing development of her TK competencies. This proactive approach in pursuing CPD opportunities demonstrates a dedication to evolving her pedagogical competencies in line with contemporary educational technologies. Such an initiative is crucial in keeping pace with the dynamic nature of technology in education, ensuring that her teaching methods remain relevant and effective in a digitally evolving academic landscape.

TPACK development. The results also show Instructor 1's ability to seamlessly integrate CK, PK, and TK. Her use of inquiry-based questions, discussion-based teaching, and scaffolding techniques exemplifies her understanding of how students learn language. She prompted students to think critically, analyze questionnaire results, and engage in argumentation, demonstrating her skill in implementing effective language teaching methodologies. She asked students to spend a few minutes observing the results to get an initial sense of the questionnaire data (class observation). After two minutes, she organized students into small groups for collaborative analysis in the Zooms breakout rooms. Students enter the breakout room with a set of questions to guide the students' analysis of the data (e.g., What patterns do you notice? Are there any surprising findings?). She observed around the break rooms to provide guidance, clarify doubts, and encourage in-depth analysis. After 5 minutes, she closed the breakout room and provided a summary of the session, highlighting key takeaways and the importance of data analysis and argumentation skills. Through this teaching slot, it can be observed that she effectively combined her content knowledge with her pedagogical skills in leading discussions and inquiry-based learning, and likely integrates technology for data analysis and representation. This integration is crucial in the TPACK framework, which emphasizes the need for teachers to blend their knowledge of content, pedagogy, and technology to create an effective learning environment.

Additionally, the CPD program facilitated her the acquisition of proficiency in utilizing Zoom, a video conferencing software. This skill acquisition was effectively applied through the employment of the software resources provided by the university. The integration of this technology into her teaching methodology not only aligns with the contemporary educational demands but also exemplifies the practical application of technological resources in enhancing the educational experience. This teaching scenario highlights the role of professional development in equipping instructors with relevant technological skills and the subsequent application of these skills in an educational setting, reflecting a commitment to modern teaching practices and resource utilization.

In summary, Lily's teaching methods, as described above, are a practical example of the TPACK framework in action. This also echoes her development in TPACK from occurrence analysis. She demonstrates how the effective integration of content knowledge, pedagogical strategies, and technological tools can create a rich and engaging learning environment for students in the field of language education during COVID-19.

Gaps of Lily's TPACK and OTL

Lily's reflections reveal her discomfort with understanding students' limited engagement and interaction. This is a crucial aspect of PK in online teaching or hybrid teaching, which means passive learning through lengthy lectures without engagement can lead to disinterest and reduced retention. Her admission that she is occasionally depressed by poor students' motivation indicates a need for more comprehensive training in CPD or technological tools advancement from university side.

She also shows limited exposure in CPD program. Though CPD provide the most frequency in TPACK development opportunities, she demonstrated limited application of technology integration in her interview.

"There may be challenges in transferring knowledge and skills acquired during CPD to real classroom settings for me. I know this kind of transfer are not hindered by contextual factors, such as the availability of technology resources or support systems within the university. Sometimes I do not know how to deliver my class efficiently with technological tool."

While CPD programs are frequently designed to provide instructors with opportunities to enhance their TPACK competencies, the translation of these opportunities into effective classroom practice can vary significantly among teachers. In the case under consideration, despite the high frequency of CPD sessions aimed at developing TPACK skills, the instructor demonstrated a limited application of technology integration in her teaching. This discrepancy highlights a crucial aspect in teacher education: the gap between professional development and its practical implementation. This suggests that the program may have insufficiently focused on developing this particular aspect of TPACK.

The OTL also mainly focused on the aspect of PK. She said:

"The one size for all method in CPD does not fit me. I am not quite good at delivery content. Sometimes, I think students did not get my point. I think it stems from my lack of various teaching method in this educational setting. However, CPD programs that do not consider the diverse needs, experiences, and learning styles of learners can be inefficient. I think effective professional development should accommodate individual differences among educators. Also, may be there should be some reflective practice post-CPD, I guess this can affect my ability to integrate new knowledge and skills into my teaching."

In this quote, she struggles with her teaching method. Without a solid grounding in PK, teachers may struggle to choose and implement instructional strategies that effectively facilitate learning. This can result in lessons that fail to engage students or accommodate diverse learning styles and needs. PK is essential for effective teaching and learning. Teachers need a strong foundation in pedagogical principles and strategies to create engaging, inclusive, and effective learning environments. However, the sudden change in teaching mode brings unexpected situation in delivery. Thus, addressing gaps in PK through targeted professional development and support is crucial for enhancing teaching quality and student outcomes.

In sum, Lily's experiences as a TNHE language teacher highlight the complexities of developing TPACK. Her case underscores the importance of a well-rounded CPD program that adequately covers all facets of TPACK, along with the value of ongoing professional development that embraces interdisciplinary approaches. The insights gleaned from her experiences can inform improvements in teacher training programs, ensuring that TNHE teachers are better equipped to handle the diverse and often unpredictable nature of student learning in language learning.

5.3.2 Tom's trajectory of TPACK and opportunities to learn

Trajectory of TPACK and OTL

Tom reflects a strong emphasis on TK learning. He recognizes the importance of technological knowledge to support online or hybrid classes while also allowing himself to explore new technological tool function by himself. His focus on developing his TK is indicative of an acknowledgment of the crucial role technology plays in modern education, particularly in online and hybrid learning environments. His proactive approach to learning and experimenting with new technological tools is a testament to his commitment to enhancing his digital literacy and pedagogical effectiveness. His approach aligns with the post-reflective sessions of CPD programs

and the university's motivation to promote active participation in technological skill learning. Such alignment indicates that the CPD sessions and university initiatives are effectively fostering a culture of continuous learning and adaptation among educators. By prioritizing TK, Tom is better equipped to design and deliver effective online and hybrid courses. This can also reflect from his interview:

"I am quite confident in digital platform and tools. For example, I like Zoom's interactive features like polls, Q&A sessions, and chat can actively engage students. These tools can be used to gather immediate feedback, conduct quick assessments, or stimulate discussions. I also like the virtual hands-up function. Students can use the 'raise hand' feature to participate in discussions or ask questions, making the virtual environment more interactive and inclusive. Sometimes, I would record a video and upload to my teaching team on Teams, and let students watch it. I can also check whether they have finished this assignment before my class."

From this quote, it can be concluded that his ability to utilize a range of digital platforms, tools, and resources is indicative of a comprehensive approach to technology integration. This includes choosing the right mix of technologies that align with the course objectives, content delivery, student engagement, and assessment strategies, which is an interaction of his TPACK development.

"My journey with integrating technology in teaching has been greatly influenced by the professional development programs I've attended. These programs have been pivotal in helping me adapt to the rapidly evolving educational technologies. The programs are not only CPD program, but also workshop from university's partnership. One of the most impactful aspects has been the hands-on training in using various educational technologies from my university. For instance, I attended a workshop where we actively engaged with Intelligence Star like interactive

whiteboards and learning management systems. This practical experience made it much easier to integrate these technologies into my teaching. I believe technology will continue to play an increasingly significant role in education even after COVID-19. It offers endless possibilities for creative and effective teaching, especially in TNHE. Continuing professional development will be key in helping educators harness these technologies to enrich the learning experience for students."

Tom also focuses on facilitating student engagement in interactive whiteboard highlights his TPACK. He understands how to teach language effectively by engaging students in interactive activities with the assistance of technology, which is a key component of TPACK. This point can also verify from his teaching style, as observed from his class, illustrates a student-centered approach. For example, he posed a hypothetical scenario about an ecosystem change (e.g., introduction of fashion pollution) and asked students to predict potential impacts of fast fashion. He facilitated learning by guiding students through the process of inquiry and discussion, helping them to develop critical thinking and reasoning skills. Students recorded their responses on a shared Zoom forum. (class observation)

Tom's case exemplifies the importance of professional development in helping educators adapt to the integration of technology in teaching. It highlights the need for CPD programs to offer practical, hands-on training in current and emerging educational technologies. The active participation in learning new technologies as advocated by the CPD sessions and university policies reflects a broader educational trend towards embracing technology-enhanced learning. This approach is critical for educators to remain relevant and effective in a technology-centric educational environment. This phenomenon also underscores the importance of incorporating technology training into pedagogical scenarios. It suggests that such programs should not only

provide foundational knowledge of educational technologies but also encourage an exploratory and self-directed approach to explore new teaching methods.

In conclusion, Tom's strong emphasis on developing his TK and TPACK to learning and integrating technology into his teaching practices exemplify the growing importance of technological proficiency in teaching. His case highlights the need for ongoing professional development and institutional support to help educators effectively integrate technology into their pedagogy.

Gaps of Tom's TPACK and OTL

Analyzing Tom's case in the context of his TPACK reveals insights into the complexities of teaching language, particularly regarding the application of pa to real-world issues and the challenges inherent in developing this aspect of content knowledge.

Tom's primary challenge involves using teaching language that is accurate yet understandable and appropriate for students to understand some skills and contents. This balance is crucial to avoid introducing content knowledge while ensuring the content is accessible. Tom's case illustrates a distinction between understanding writing skills (how to paraphrase) and effectively applying them (effective paraphrasing sentences). While he acknowledged the importance of paraphrasing quote when cite other people's works, his ability to implement this in teaching practice is limited. For example, when he explained original texts and their paraphrased versions, despite acknowledging the importance of paraphrasing, he still struggled to effectively demonstrate the nuances of paraphrasing, such as how to sufficiently alter the sentence structure and word choice while retaining the original meaning. Although he used slides to present the definition of paraphrasing and differentiate it from direct quoting and plagiarism, he faced challenges in thoroughly conveying this skill during the teaching session. This gap points to a

nuanced understanding of TPACK, where recognizing the value of application is one step, but his teaching practice shows limited evidence of this application. This discrepancy indicates a challenge in translating theoretical understanding into practical teaching strategies.

The minimal opportunities provided in his professional development training, teaching practices and university contexts, further contribute to this challenge. Both professional development training and university contexts focus on TK and TPACK development, while teaching practices has limited opportunities in CK development, which theoretically includes applying knowledge to new problems, did not translate into sufficient practical implementation in Tom's content teaching.

Tom's experience underscores the need for more comprehensive support in CPD, teaching practices and university contexts, particularly in developing the skills to apply theoretical concepts in language learning to understanding and practicing contexts. Professional development should extend much on content knowledge to include strategies for integrating pedagogies with content implementation, thereby enhancing their deeper understanding of language skills.

In conclusion, Tom's case highlights the intricate relationship between understanding language skills, applying them in teaching, and the need for targeted professional development. It emphasizes the importance of not only knowing language skills but also understanding how to make this content relevant and applicable to students' understanding and valuing. His experience serves as a valuable case study in the ongoing discourse on effective university contexts, teaching practices and the professional development of language teachers.

5.3.3 Lucy's trajectory of TPACK and opportunities to learn

Trajectory of TPACK and OTL

CK development. Lucy' focus on CK as a strength in her teaching practice is highlighted by her attentiveness to the diverse ideas of her students. For example, in a reading class, she presented a case study of fashion rubbish generated by fashion industry. She asks students to analyze the physical waste and environmental impact caused by the fashion industry. The term is used to describe discarded materials, unsold clothing, or the byproducts of manufacturing processes that contribute to environmental pollution. She encouraged students to ask questions during the reading activity. When a student expresses a misconception about this term used to describe clothing considered to be of poor quality, out of style, or otherwise undesirable, she takes the opportunity to address this common misunderstanding and clarifies with real-world examples. This approach aligns with the constructivist theory of learning, which posits that understanding students' pre-existing knowledge and beliefs is crucial for effective teaching. Her focus on her students, especially considering their age and developmental stage, is evident in her teaching approach. This student-centered strategy is crucial in hybrid teaching environment, where the goal is to prioritizes the needs, preferences, and active participation of students in the learning process, catering to diverse learning styles and circumstances.

PK development. Lucy's development in understanding PK is supported by her teaching practice. This experience provided her with strategies to explore and understand students' learning needs. She showed a stronger understanding of how to satisfy underachieved students' learning needs. This might be attributed to her teaching experiences with lower-performing group. Teaching lower-performing groups often exposes instructors to a variety of learning challenges,

such as difficulties in comprehension, lack of motivation, and gaps in foundational knowledge. This exposure can deepen her understanding of the diverse needs of underachieving students.

"As a module leader, I need to keep an eye on lower-performing students. So, I always teach the last groups. Teaching lower-performing students often requires extra patience and empathy. My experience with these groups has helped her develop a more empathetic teaching approach, which is crucial for supporting underachieving students. Such teaching experiences usually demand more individualized feedback and support, especially online teaching. Because I could not talk with students face to face when I meet him or her in the teaching building like before. I need to hone my skills in providing constructive, personalized feedback that addresses specific learning issues, then I can give students a supportive learning environment."

Lucy's stronger understanding of underachieving students' learning needs, developed through her teaching experience with lower-performing groups. This opportunity to learn in teaching experience would have equipped her with valuable skills and insights in her pedagogical knowledge. These include the ability to provide differentiated instruction, empathy, customized support, and effective communication, all of which are crucial for addressing the diverse requirements of underachieving students.

TK development. Lucy's participation in CPD offered her a lot of opportunities to develop her understanding of various teaching digital tools and how to engage students in virtual classroom (interview). Despite having more opportunities to learn about using collaborative tools (e.g., Google Workspace, Microsoft Teams), her knowledge in technology area was not as strong as in other domains. For example, in a pop art reading class, she conducted a class discussion without leveraging any digital tools for real-time engagement or feedback (e.g., polls or quizzes) (class observation). Although Microsoft Teams was mentioned as a communication platform, it was

underutilized during the lesson. There was no demonstration of features like channels for group discussions or assignments (class observation). This discrepancy highlights that the quantity of learning opportunities does not always directly correlate with the strength of knowledge acquisition.

"Yes, we have lots of courses from CPD and workshops from university to support digital tools study and application. However, I think they are only tool and I do not need to many tricks in my class. I think the essence of teaching is how you teach, not how you use. Also, I am not that good at these digital tools. It took me a lot of time to master them. Maybe younger teachers are much better than me. Sometimes, in my class, I just forget where or which function I could use. And because I am not good at it, it also costs me more time to interact with students with various function. It happened twice. So, from my opinion, digital tools are not that efficient for me, and I am not so passionate with it as some teachers."

From her quote, it indicates that her individual comfort levels and prior experience with technology significantly influence the ability to integrate new tools into teaching. Even with training, some educators may find it challenging to adapt to new technologies, especially if they have had limited prior exposure or lack confidence in their technical skills.

Lucy's case underscores the need for CPD programs or university contexts to consider the developmental stages of instructors' and the corresponding appropriateness of different previous levels. Programs should equip teachers with strategies and courses tailored to various age groups and learning contexts.

Contrasting Lucy's experience with that of Lily and Tom, who demonstrated stronger PK and CK, suggests that teacher experiences significantly influence the development of specific TPACK domains. Unlike Lily, who connects her understanding of language skills (CK) with her

understanding of how to deliver (PK), Lucy's focus is more on the relationship between her knowledge of students' ideas (CK) and her teaching methods (PK). This distinction underscores the multifaceted nature of TPACK and the different ways in which teachers may interpret and apply these sub-domains.

In summary, Lucy's experiences in her teaching practice reveal important aspects of TPACK development. Her stronger knowledge in certain pedagogical knowledge over others, influenced by her teaching context with lower-performance students, highlights the importance of aligning professional development with both the teachers' and their students' needs. This alignment is essential for fostering effective and developmentally appropriate teaching practices. Her approach to language teaching, characterized by a strong focus on understanding and addressing her students' ideas and requirements, highlights the critical role of PK in TPACK development. Her case illustrates how professional development and classroom experiences contribute to the development of a teacher's TPACK, particularly in the domains of PK and CK, and underscores the importance of teachers' responsiveness to students' individual learning needs in language education.

Gaps of Lucy's TPACK and OTL

Academically analyzing Lucy's challenges in her TPACK development, particularly in her lack of TK in understanding on how to effectively use teach with different groups, reveals several key educational issues and development areas:

Her lack of familiarity with digital tools and age exacerbates this challenge, as she expressed uncertainty about her utilization of some learning management system functions. This indicates a need for professional development focused on age-specific pedagogical strategies. Also, her lack of passion for technology makes her receive minimal support in professional development from

CPD programs and university contexts. She thought she got limited opportunities for learning how to use technological tools effectively, particularly when addressing interactive issues in online teaching. This minimal focus in her CPD could contribute to her struggles. Her dilemma about to what extent introduce technology into online classes or her hybrid classes reflects a common challenge in TK training. Deciding when to introduce specific terminology is critical for maximizing understanding and engagement.

Comparing Lucy's approach with that of other teachers like Lily and Tom, who tend to passionately learn digital tools at the beginning of lessons, underscores diverse strategies in TPACK development training. Various approaches have implications for instructors' understanding and engagement.

Despite these challenges, Lucy's attentiveness to her lower-performance students' language use and conceptual struggles indicates a strong PK. This aspect of her TPACK, while less evident in her teaching practices because of her insufficient lower TK, is still vital for informing effective language instruction.

In summary, Lucy's experience points to the complexities involved in effectively integrating CK and PK into teaching practices, especially for low-performance learners. It highlights the need for targeted professional development that addresses specific challenges in learning opportunities, as well as the importance of understanding the developmental stages of TPACK when teaching practical technological knowledge like digital tools use. Her case also demonstrates the significance of TPACK in shaping language teaching approaches and addressing student learning needs.

5.4 Summary

The case studies of three language teachers provide valuable insights into their TPACK competencies and the varying degrees of support they received for their development. These analyses offer a rare glimpse into how such teachers apply their TPACK in actual teaching scenarios, an area not extensively explored in existing literature.

Three primary themes emerge from case analysis:

Evident knowledge through supported development. The study finds that these language teachers most effectively utilized their knowledge in practice when they received adequate support for its development. For instance, their grasp of technological tools became apparent after participating in the CPD programs. This indicates a direct correlation between the opportunities provided for learning specific aspects of CPD programs and their application in classroom settings.

Integration of multiple knowledge aspects. The teachers were observed to concurrently draw upon various dimensions of their knowledge to facilitate students' language skills. For example, Lily integrated her differentiated instruction method in academic speaking with her ability to engage students writing practice, recognizing that students have varying backgrounds, learning styles, and proficiencies. Instructor similarly combined her understanding of content and teaching methods. This simultaneous utilization of different knowledge sub-domains highlights the multifaceted nature of online or hybrid language teaching and suggests the need for more nuanced support to help teachers understand and apply these interconnected aspects of their knowledge.

Varied struggles with knowledge sub-domains. The teachers displayed differing levels of proficiency across various knowledge sub-domains, often struggling with those that received minimal support during their training. For example, effectively using teaching method with assistance of technology to students was a common challenge, likely due to limited learning

opportunities in PK area. This underlines the need for more comprehensive support in areas crucial for CPD program, teaching practices, and university contexts, such as the use of language, understanding its applications, and contextualizing science concepts within social, political, and historical frameworks.

Overall, while these language teachers had similar learning opportunities for developing TPACK, they exhibited subtle differences and many similarities in applying this knowledge in their teaching practices. This complexity underscores the necessity for robust support in teacher professional development to assist them in becoming all-round instructors.

6. Discussion and Conclusion

6.1 From Study 1: development in TPACK

6.1.1 TPACK as four correlated factors

This study conducted an empirical examination of the TPACK framework, adapted to the specific context of language instruction in TNHE institutions. The investigation involved testing a TPACK measurement model that conceptualized TPACK into four distinct interrelated dimensions: TK, PK, CK, and the synthesized construct of TPACK, each pertaining to the domain of language teaching.

Following the approach of Schmidt et al. (2009), the research adapted the existing instrument, initially adopted for general education across various subjects at the elementary level and modified it for the specialized setting of education. The methodological application of EFA and CFA yielded results that substantiated the four-factor model, with each factor representing a unique yet interdependent domain of knowledge. The analysis resulted in moderate positive correlations among the knowledge constructs, highlighting a particularly strong relationship between PK and TPACK. This suggests that the integration of pedagogical strategies and

technology is central to teaching effectiveness. The correlations imply that an integrated understanding of TK, PK, and CK is fundamental to the development of comprehensive TPACK.

In sum, the study affirms the multidimensional nature of the TPACK framework and its applicability in the academic English teaching context within TNHE settings, as evidenced by both statistical findings and educator testimonies. The collective data underscore the necessity of a harmonized interplay among technology, pedagogy, and content knowledge to foster effective language instruction.

6.1.2 Positive prediction of TK and PK on TPACK

Within SEM analysis, both TK and PK were found to be significant contributors to TPACK, suggesting that these domains are integral to language instructors' perceived ability to integrate technology into their teaching effectively. Conversely, CK did not emerge as a significant predictor of TPACK in this context, suggesting that in practical experience, the theoretical nature of the content did not readily align with technology integration strategies. These findings suggest the ability to teach language effectively with technology may depend more on instructors' pedagogical strategies and technological proficiency than on their content expertise.

PK predicted TPACK. Within the specific setting of TNHE language education, the study's findings underscored that PK was a pivotal determinant of TPACK. The data suggest that a robust foundation in PK significantly improve the capacity to integrate technology into academic English instruction. Furthermore, findings have highlighted the essential role that pedagogical knowledge plays in enhancing TPACK. The marked correlation between language instructors' PK and TPACK may be attributed to the presence of a robust curricular focus on pedagogical strategies, underscored by coursework and practical teaching experiences. Such experiences likely contribute to the instructors' self-confidence, reinforcing the integration of technology into their pedagogical

practicum. This interconnection emphasizes that comprehensive teacher professional development, with a focus on pedagogical proficiency, is instrumental in cultivating a good basis for the development of TPACK in language instruction.

TK predicted TPACK. In the context of TNHE language instruction, findings revealed that language instructors' TPACK was significantly influenced by their TK. This indicates that instructors who have a positive perception of TK believe it has a beneficial impact on their TPACK.

This conclusion aligns with qualitative data obtained from interviews. Language instructors conveyed the importance of technology use in teaching English within TNHE institutions, particularly for lower-performance students. They expressed concerns that integrating technology might overburden students who are already facing challenges in academic English study, suggesting a need for careful consideration of students' existing technology skills.

The contributing factor to the comparatively weaker association between TK and TPACK, as opposed to PK and TPACK, could be attributed to the instructors' need for more meaningful engagement with technology in their specific teaching contexts. This suggests a need for professional development activities that more closely align technology use with pedagogical aims, thereby strengthening the connection between technological proficiency and TPACK.

To maximize the impact of various factors on TPACK, it is imperative that educators adopt strategies facilitating the efficacious use of technology alongside sound pedagogical practices. Professional development should thus be equipped towards modeling TPACK in a way that reflects these integrated applications, thereby enhancing teachers' overall TPACK framework in language instruction.

CK did not predict TPACK. In this investigation, the empirical results suggested that the TPACK of language instructors in TNHE settings was not significantly influenced by their CK.

This finding implies that possessing extensive CK does not markedly enhance the TPACK framework for TNHE language educators.

One possible explanation for this could lie in the intrinsic attributes of language as a discipline. Language often emphasizes the development of critical literacy skills, which traditionally depend on intensive engagement with text, in-depth analysis, and amount of writing exercises—processes that are inherently cognitive and may not derive significant added value from technological integration. For instance, the critical analysis of literature, a staple in academic English curricula, typically entails a methodical examination of narrative elements and thematic constructs, activities where technology acts only as an assistant tool.

6.1.3 Positive TPACK change and development

The study's findings indicate significant changes in TPACK over the course of three semesters. Additionally, there were noteworthy increases in TK, PK and CK when comparing data collected before and after each semester.

The study also assessed the effect sizes of these changes, with the largest effect size observed in TPACK and the smallest in technology use. Notably, PK showed a substantial change in a large effect size, which aligns with the language teachers' perception of having a higher level of knowledge in TPACK and pedagogy. These language instructors expressed confidence in their technological abilities but also indicated a desire for more time and practice to further develop their tech skills.

Interestingly, the self-report data collected from the instructors consistently demonstrated a positive change across the three semesters. This suggests that teaching experience during the COVID-19 pandemic had a positive impact on the teachers' belief that they had improved in their

TPACK, as evidenced by the growth in technology knowledge, pedagogical expertise, content knowledge, and overall TPACK.

For teacher educators and researchers, this study provides new perspectives that can inform the TPACK development. It underscores the importance of understanding the interplay between different knowledge domains in the design and delivery of technology integration within language teaching curricula. From an administrative standpoint, the findings offer valuable information for the creation and implementation of professional development initiatives. By highlighting the significance of TK, CK, and PK in relation to TPACK, the study assists in identifying focus areas for teacher training, particularly in enhancing teachers' capabilities to effectively integrate technology into their teaching practices.

In the era of COVID-19, which has prompted an accelerated shift towards digital learning modalities, the insights explored from this study are particularly pertinent. Teacher educators tasked with designing technology-integrated courses or updating curricula can utilize these findings to better equip instructors for the demands of remote and hybrid learning environments.

Furthermore, the study provides actionable information for instructors regarding the integration of technology into language curricula. Understanding the dynamics of TPACK in the context of academic English instruction within TNHE settings enables language teachers to more effectively incorporate technology into their pedagogical strategies, thereby potentially enhancing student engagement and learning outcomes.

In summary, the significance of this study lies in its creation to inform and guide TNHE language teachers, administrators, researchers, and educational technologists in the pursuit of optimizing the TPACK framework for the benefit of language education. It contributes to the ongoing dialogue surrounding best practices for technology integration in education and serves as

a resource for the continual evolution of pedagogical methodologies in response to technological advancements and changing educational landscapes.

6.2 From Study 2: OTL on TPACK development

The study's focus on three language teachers over three semesters provides insights into the development of their TPACK across multiple sub-domains. It highlights the importance of providing targeted support for developing specific knowledge areas and acknowledges the complexity of online language teaching, which requires a nuanced understanding of various knowledge sub-domains and their application in the classroom.

6.2.1 Well-rounded teacher: potential trajectories of TNHE instructors

The concept of "well-rounded teacher" is introduced, referring to high quality teachers who are well rounded and balanced in terms of each of knowledge, skills and personal qualities (Tao et al., 2024). The research examines language teachers who have foundational understanding and readiness for continuous development in teaching language. Exploration on their trajectory in developing a deeper understanding of teaching practices illustrates the importance of teaching experiences, university contexts and professional development programs in shaping their knowledge and teaching practices.

The concept of "well-rounded teachers" in language teaching is pivotal in this study. This term refers to language teachers who possess a foundational base for ongoing knowledge and practice development. Avraamidou & Zembal-Saul (2010) and Hollon et al. (1991) provided a perspective on what constitutes being a well-rounded teacher, focusing less on the quantity or extensiveness of knowledge and practices, and more on the quality or solidity of the foundational knowledge and teaching skills, coupled with the ability to continually evolve and learn throughout one's teaching career.

6.2.2 Instructors' knowledge in and knowledge for teaching

The concept of "Knowledge in and knowledge for" refers to dual dimensions of teachers' expertise: knowledge that is essential for teaching (the "for" aspect) and knowledge actively applied during the teaching process (the "in" aspect) (Vidergor, 2023).

Teachers' knowledge in practice involves examining the knowledge that is observable and demonstrable within their teaching activities (Wien, 1996). This concept recognizes that knowledge in practice encompasses the visible application of knowledge in the classroom, accessible not only to educational researchers but also to students. For instance, a teacher's strong CK might be evident in a learning setting. However, this same knowledge may not always be actively utilized or visible in their day-to-day teaching practice. A lack of visible application of TPACK knowledge in classroom teaching could potentially limit students' opportunities to learn language effectively. In this study, language teachers were observed regularly employing their TPACK knowledge in practices, particularly after being exposed to learning opportunities focused on TPACK and its subdomains.

And an integrated TPACK Development Model is proposed to improve the interplay between "knowledge in" and "knowledge for" with the TPACK framework. Figure 14 represents the Integrated TPACK Development Model, "knowledge in" is represented by the individual circles of TK, PK, CK and TPACK. These circles reflect the theoretical understanding of each domain. "Knowledge for", on the other hand, is demonstrated by the practical application elements from OTL aspects such as reflective integration, dynamic professional development, and collaborative learning communities, represented by the rectangles and the arrows showing the flow between theory and practice. The model emphasizes the transformation of "knowledge in" (theoretical) into "knowledge for" (practical application) through these mechanisms.

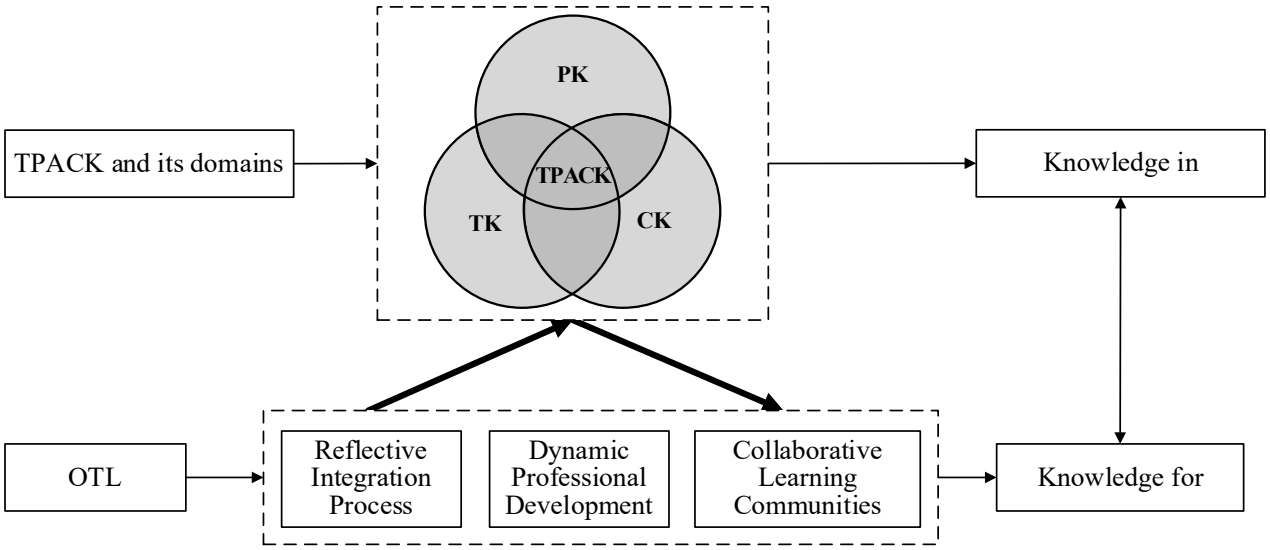

Figure 15 Integrated TPACK Development Model

In Reflective Integration Process, teachers are encouraged to engage in cyclical reflective practices, assessing how their technology, pedagogy, and content knowledge are applied in the classroom and what outcomes they produce. Dynamic Professional Development is ongoing and adaptive, designed to update teachers on the latest in TPACK domains and tailored to individual teacher needs based on their reflective practices. While Collaborative Learning Communities refer to communities of practice within their institutions and with broader online communities, sharing TPACK strategies and resources.

6.2.3 Opportunities to learn TPACK across contexts

The study proposes a cyclical interaction between opportunities supporting PK, TK and TPACK, challenging the traditional view that understanding PK and TK always precedes the development of TPACK. Instead, it suggests that engaging in opportunities supporting TPACK could highlight limitations in teachers' TK, CK, PK, encouraging them to seek further learning in teaching.

This exploration is significant as relatively few studies (Kager, 2023; Rich, 2021; Abakah, 2023) have concurrently examined the role of continuous professional development programs,

actual teaching experiences and university contexts in supporting teachers' knowledge development, with most research focusing on teaching practice rather than knowledge per se. It identifies that a CPD program plays a vital role in this development process. Additionally, the combination of the CPD and actual teaching experiences contributed to the development of the teachers' TPACK. These findings suggest the need for a more comprehensive approach in continuous professional development framework to cover these aspects. This aspect is in line with findings from previous studies (Van Driel et al., 2002).

Difference change trends also confirmed the effectiveness of OTLs in the development of TPACK. Knowledge development can vary significantly among individuals due to factors, including prior knowledge and experience, learning styles, professional development design, access to resources, motivation and attitudes**: An individual's motivation to integrate technology into teaching and their attitudes towards technology use can significantly impact the effectiveness of TPACK development. Those who are intrinsically motivated and have a positive attitude towards technology are more likely to engage deeply with learning opportunities and apply their knowledge in practice and so on. Recognizing and addressing these factors can lead to more effective TPACK development experiences for educators.

In summary, the study contributes to the academic understanding of how CPD programs, teaching experiences and university contexts can collectively enhance teachers' TPACK. It highlights the importance of providing well-rounded learning opportunities that not only focus on the practical aspects of teaching science but also on the comprehensive development of various sub-domains of content knowledge crucial for effective teaching.

6.3 Limitations and future research

6.3.1 Study 1

The generalizability of the results is not assured beyond the studied context without conducting replication studies in diverse educational landscapes. Such replications would help ascertain the universality of the observed relationships among the TPACK constructs and determine the applicability of the insights gained to other language teaching scenarios.

Additionally, the study focused on a model comprising four correlated factors of TPACK—TK, PK, CK, and the integrative TPACK construct. While these are central to the TPACK framework, it is recognized that there are supplementary factors that may influence language teachers' self-efficacy and development in technology integration. Notably, this study did not account for legal and ethical considerations that could bear upon teachers' TPACK development and their practical application. Issues such as digital privacy, intellectual property, and ethical use of technology in the classroom are pertinent to the comprehensive understanding of TPACK in practice.

Future research endeavors could benefit from incorporating these additional elements to provide a more holistic view of the factors affecting TPACK development among language teachers. This expanded perspective would be valuable in designing professional development programs and informing policy decisions that support effective technology integration in language education.

The research revealed that CK did not emerge as a significant predictor of TPACK, which raises considerations about the experiences of language teachers with technology integration during their practicum and coursework. There is a possibility that language teachers may not have been adequately exposed to or practiced with technology integration strategies tailored for

language content. To address this gap, language instructors are encouraged to provide with opportunities to engage with and evaluate technological tools that support exploration and acquisition of language teaching.

Another explanation for the lack of significant prediction by CK could be the distinct nature of language, which may not necessitate the same level of technological integration as other more technologically reliant subjects. Consequently, there is an opportunity for future research to investigate into intervention studies that explore the integration of specific technological tools within language teaching, coupled with appropriate pedagogical methods. Such studies could provide insights into how these interventions affect language teachers' TPACK development and their motivation to incorporate technology into English instruction.

Moreover, future research should consider expanding upon the TPACK framework by validating a model that includes all seven correlated factors. This could involve the development of more refined survey items that accurately measure the nuanced aspects of each mediated factor, particularly Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Pedagogical Content Knowledge (PCK). The observed non-significance of CK in predicting TPACK may indeed be a product of indirect effects mediated through TCK, PCK, or both.

6.3.2 Study 2

This study focuses on investigating how three TNHE teachers developed TPACK within various contexts during their three semesters of teaching. The study examines the types of learning opportunities provided by CPD program, teaching practices and university contexts, and how these opportunities supported the development of the teachers' TPACK. This investigation is crucial for understanding the process of becoming a "well-rounded teacher" in TNHE language teaching and

has suggestions for individuals involved in teacher education, curriculum development, and university staff in terms of offering continuous assistance to enhance teachers' knowledge development.

However, the study acknowledges certain limitations. Firstly, the focus on only three TNHE language teachers means the findings may not be widely generalizable, which means it does not claim to be representative of all teachers' experiences.

Secondly, the specific CPD programs, teaching experiences and university contexts involved in this study may not mirror other such programs nationally or globally. While the study provides valuable insights into how this particular program supported language teachers TPACK development, these insights are somewhat speculative and not necessarily indicative of other CPD programs, teaching experiences or university contexts. Future research should expand to include a broader range.

Lastly, the study was limited in its ability to capture all the various experiences and resources that could contribute to the development of the teachers' TPACK during their COVID-19 period of teaching. Important elements such as professional development experiences and curriculum materials, known to influence teachers' knowledge development, were not fully explored. This limitation suggests a need for further research incorporating a wider array of sources.

6.4 Contribution to Knowledge Science

This doctoral research significantly contributes to the field of knowledge science, particularly in the domain of teaching knowledge for language instructions in TNHE institutions. The study is anchored in the creation and application of meta-knowledge, a concept central to knowledge science. Meta-knowledge refers to the knowledge about knowledge itself, which includes

understanding how to collect, organize, validate, and apply domain-specific knowledge effectively across various fields.

The research focuses on fostering TPACK development within the context of opportunity to learn. By doing so, it aims to generate meta-knowledge that not only guides the development and implementation of TPACK but also enhances instructors' opportunities to learn in adopting this knowledge. This creation of meta-knowledge is vital, as it provides an in-depth view for educators and decision-makers in the field, guiding them in resource allocation, policy formulation, and effective implementation of online teaching strategies.

Furthermore, this dissertation contributes to the practical aspects of knowledge science by offering actionable insights and policy implications for policymakers, institutional leaders, and instructors. It equips them with the necessary meta-knowledge to make informed decisions about improving the efficiency and quality of TPACK development. The study, therefore, has practical relevance for education providers and instructors.

The creation of this meta-knowledge is particularly significant as it transcends the boundaries of mere domain knowledge. It empowers educators to initiate and implement CK, PK, TK and TPACK effectively. These knowledges, once developed and applied, serve not just as domain-specific knowledge but evolve into a broader body of meta-knowledge. This meta-knowledge can guide students towards more effective learning and contribute to the recovery and transformation of TNHE, as well as the broader field of online teaching.

In essence, the thesis positions itself as both a product of and a contributor to knowledge science. It is guided by established meta-knowledge in the field and, in turn, generates new meta-knowledge that informs and shapes future educational practices and policies. This dual role

underscores the dynamic and impactful nature of research within the knowledge science domain, particularly in addressing the evolving challenges and opportunities in online teaching.

Publications

1. Scholarly Journals

○ Scholarly journals:

1. Wang, J.; Kim, E. The Development and Validation of an Instrument to Collaborative Teaching Assessment under the Impact of COVID-19 through the SECI Model. *Sustainability* 2023, *15*, 9540. https://doi.org/10.3390/su15129540
2. Wang J, Kim E. Exploring Changes in Epistemological Beliefs and Beliefs about Teaching and Learning: A Mix-Method Study among Chinese Teachers in Transnational Higher Education Institutions. *Sustainability*. 2023; 15(16):12501. https://doi.org/10.3390/su151612501

○ Conference proceedings:

3. Wang, J., Kim, E, Yuizono, T. (2023) *Assessing Collaborative Teaching Under the Impact of COVID-19 Pandemic: Instrument Development in the Context of the SECI Mode.* The IAFOR International Conference on Education in Hawaii (IICE2023). https://scholar.google.com/citations?view_op=view_citation&hl=en&user=qPFfjqwAAAAJ&sortby=pubdate&citation_for_view=qPFfjqwAAAAJ:BqipwSGYUEgC
4. Wang, J., Kim, E. (2023) *Knowledge Management Enablers and Impacts on Institutional Accreditation Outcomes: An Empirical Study of BGA Accreditation in China.* The IAFOR Conference on Educational Research & Innovation (ERI2023). https://papers.iafor.org/wp-content/uploads/papers/eri2023/ERI2023_69952.pdf
5. Wang, J. & Kim, E. (2023). *Mapping the Field of Quality Assurance and Transnational Higher Education Through a Bibliometrics Analysis* The 2nd Paris Conference on Education (PCE2023).

○ Abstract accepted

6. Wang, J. & Kim, E. (2023). *Exploring Asset Management Performance: A Knowledge Management Perspective* The 17th World Congress on Engineering Asset Management (WCEAM 2023).

2. Conference Presentations

1. Wang, J. & Kim, E. (2023). *Assessing Collaborative Teaching Under the Impact of COVID-19 Pandemic: Instrument Development in the Context of the SECI Model* The IAFOR International Conference on Education in Hawaii (IICE2023).
2. Wang, J. & Kim, E. (2023). *Knowledge Management Enablers and Impacts on Institutional Accreditation Outcomes: An Empirical Study of BGA Accreditation in China* The IAFOR Conference on Educational Research & Innovation (ERI2023).
3. Wang, J. & Kim, E. (2023). *Mapping the Field of Quality Assurance and Transnational Higher Education Through a Bibliometrics Analysis* The 2nd Paris Conference on Education (PCE2023).
4. Wang, J. & Kim, E. (2023). 17th World Congress on Enginerring Asset Management (WCEAM 2023)

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Appendices

Appendix 1 Survey Instrument

Your answers in this section will help us understand the diverse backgrounds and experiences of transnational higher education language instructors. Your personal data will be kept confidential and will only be used for research purposes.

1. Gender:

- [ ] Male

- [ ] Female

- [ ] Prefer not to say

2. Highest educational qualification:

- [ ] Bachelor's Degree

- [ ] Master's Degree

- [ ] Doctorate

3. Years of experience as a language instructor in TNHE institutions:

- [ ] Less than 1 year

- [ ] 1-5 years

- [ ] 6-10 years

- [ ] Over 11 years

4. Primary mode of instruction during COVID-19:

- [ ] Fully online

- [ ] Hybrid (combination of online and face-to-face)

5. Technological tools familiarity prior to COVID-19:

- [ ] Extensive experience with online teaching tools

- [ ] Moderate experience
- [ ] Limited experience
- [ ] No experience

Please indicate your agreement with each statement below using the following scale:

1. Strongly Disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree

Technological Knowledge (TK)

1. I can troubleshoot and resolve technical issues related to language teaching platforms, such as Teams, Zoom etc.
2. Adapting to new technology tools used for language instruction comes naturally to me.
3. I stay updated with emerging technologies relevant to transnational language education.
4. I regularly experiment with new digital tools to enhance my language teaching.
5. I am familiar with a broad spectrum of technologies suited for language teaching in a transnational context.
6. My technical proficiency supports my effectiveness as a language instructor in transnational settings.

Pedagogical Knowledge (PK)

7. I am skilled at evaluating language proficiency and performance of students from diverse cultural backgrounds.

8. I can tailor my teaching methods to accommodate the diverse linguistic backgrounds of my transnational students.
9. I employ multiple assessment strategies to gauge the language comprehension of my students.
10. I am adept at using various teaching strategies that cater to the unique needs of a transnational language classroom.
11. I am attuned to common language misconceptions that arise from foreign instructors' diverse cultural contexts.
12. I have strategies in place to manage a virtual classroom that hosts students from multiple regions within China.

Content Knowledge (CK)

13. I have a strong grasp of English grammar rules and can effectively teach these concepts to students with varying levels of proficiency.
14. I am knowledgeable about a wide range of English vocabulary, idioms, and colloquial expressions, and can teach their appropriate usage in different contexts.
15. I understand the nuances of English pronunciation, including regional accents, and can help students improve their spoken clarity and comprehension.
16. I am proficient in incorporating critical thinking to analyze, evaluate, and synthesize information in English texts.
17. I have expertise in English speaking skills, enabling students to understand and interpret spoken English in diverse scenarios, from everyday conversations to academic lectures.
18. I possess skills in teaching English writing, from basic sentence construction to composing advanced essays and reports.

Technological Pedagogical Content Knowledge (TPACK)

19. I can seamlessly integrate technology tools that complement the linguistic content and pedagogy of my class.
20. I merge content, technologies, and teaching approaches from my training to effectively teach in virtual classroom.
21. I can guide my peers in blending content, technologies, and pedagogical strategies suited for online language instruction.
22. I am skilled at selecting technologies that enrich the linguistic content of my lessons.
23. My teaching approach adeptly combines linguistic content, relevant technologies, and pedagogical strategies suitable for transnational education.

Thank you for your response.

Appendix 2 TPACK Classroom Observation Protocol

Observer Information:

Name of Observer:

Date of Observation:

Time of Observation:

Class Observed:

Instructor Name:

1. Content Knowledge (CK) Observation:

Question 1: How does the instructor demonstrate a deep knowledge of the subject matter being taught?

Question 2: Are there clear examples of the instructor making the content accessible and relevant to students?

Question 3: Does the instructor make connections to prior knowledge or real-world examples?

2. Pedagogical Knowledge (PK) Observation:

Question 1: What instructional strategies does the instructor use to engage students in learning?

Question 2: How does the instructor differentiate instruction to meet diverse student needs?

Question 3: Can you identify classroom management techniques that support a positive learning environment?

3. Technological Knowledge (TK) Observation:

Question 1: What technology does the instructor use to support teaching and learning?

Question 2: Is the technology used effectively to enhance student learning?

Question 3: How does the instructor troubleshoot or adapt when technological issues arise?

4. TPACK Integrated Observation:

Question 1: How does the instructor integrate CK, PK, and TK to promote student understanding and application of concepts?

Question 2: Can you provide examples of how the instructor's practice reflects a sophisticated understanding of TPACK?

Question 3: How does the instructor evaluate the impact of integrated TPACK on student learning outcomes?

Appendix 3 Follow-up Interview Protocol after Class Observation

This is a follow-up interview protocol following classroom observations within the TPACK framework should facilitate deeper understanding of the instructor's teaching practices and the reasoning behind them.

Date of Interview:

Interviewee (Instructor) Name: Lily/ Tom/Lucy

Reference to Observation Date/Time:

Introduction:

- Briefly explain the purpose of the follow-up interview.

- Reiterate the confidentiality and use of the information gathered.

- Seek consent for recording the interview for accuracy.

Content Knowledge (CK) Follow-Up Questions:

1. Clarification on Content Delivery:

    - You utilized [specific example] in your lesson. Could you elaborate on how you decided to present this content?

2. Adaptation and Relevance:

    - During the observation, you connected the lesson to [real-world example/prior knowledge]. Can you discuss how you typically integrate these connections into your teaching?

Pedagogical Knowledge (PK) Follow-Up Questions:

1. Engagement Strategies:

    - Can you describe in more detail the thinking behind your choice of [specific instructional strategy observed]?

2. Differentiation and Classroom Management:

- We noticed [specific differentiation technique/classroom management strategy]. Could you share more about how you develop and implement these techniques?

Technological Knowledge (TK) Follow-Up Questions:

1. Technology Integration:

- You chose [specific technology] for the activity. Can you discuss the process you went through to select this technology?

2. Technology Troubleshooting:

- Can you talk about a time when you had to troubleshoot or adapt your lesson due to technological issues, perhaps even during the observed lesson?

TPACK Integrated Follow-Up Questions:

1. Integration of TPACK:

- How do you plan and reflect on the integration of CK, PK, and TK in your lessons?

2. Evaluation of TPACK on Learning:

- Can you provide an example of how you assess the impact of this integration on your students' learning outcomes?

Open-Ended Questions:

1. Reflective Practice:

- Is there anything else about your lesson that stood out to you upon reflection?

- Are there any additional thoughts you would like to share about your instructional practice or professional development needs?

2. Emergent Questions:

- [Insert emergent questions noted during the observation here for discussion.]

Conclusion:

- Ask if there’s anything the instructor would like to add or clarify.

- Thank the instructor for their time and participation.

Appendix 4 CPD Program for Teachers' Enhancement Delivered by Southampton International College of Dalian Polytechnic University

Course	Content	Hours
Course 1	Digital Tools and Platforms for Language Instruction • Familiarization with various language learning apps, software, and online platforms that enhance language instruction. • Practical demonstrations and hands-on experience with digital tools suitable for different language skills.	2 hours
Course 2	Designing Technology-Enhanced Language Lessons: • Strategies for designing lesson plans that integrate technology effectively to enhance language learning. • Adapting existing materials or creating new digital content for language instruction.	2 hours
Course 3	Online Language Teaching and Learning: • Strategies for effective online language instruction, including synchronous and asynchronous approaches. • Utilizing digital whiteboards, video conferencing, and online collaborative tools.	2 hours
Course 4	Assessment and Feedback in Technology-Integrated Language Teaching: • Incorporating technology in online assessments for language learners. • Providing timely and meaningful feedback using digital tools.	2 hours
Course 5	Interactive Multimedia for Language Learning: • Creating interactive multimedia content, such as videos, audio clips, and interactive exercises, to engage language learners. • Integrating multimedia to enhance listening, speaking, reading, and writing skills.	2 hours

Appendix 5 CPD Program for Teachers' Enhancement Delivered by University of Nottingham Ningbo China

Delivery mode	weekly live sessions and ongoing asynchronous activities	
Duration	a period of 6 weeks, 2 hours per module	
Module	Topic	Description
Module 1	Technology-assisted Teaching Framework Overview	Understanding technology-assisted framework
Module 2	Pedagogical Strategies	Effective pedagogical strategies for online teaching and learning
Module 3	Content Adaptation	Adapting subject content for digital delivery, considering the cultural context of Chinese learners.
Module 4	Technological Tools	Hands-on training in various educational technologies and platforms.
Module 5	Designing Online Assessments	Creating assessments for online environments that are fair, reliable, and valid.
Module 6	Culturally Responsive Teaching	Strategies for ensuring that digital learning is inclusive and responsive to diverse learners.

Appendix 6 CPD Program for Teachers' Enhancement Delivered by Institute of Creativity and Innovation at Xiamen University

CPD Program: Integrating Technology in Education				
Duration	5 days (2 hours per day)	Mode	Hybrid (combination of online and in-person sessions).	
Objective	Enhance teachers' ability to effectively integrate technology in their teaching			
Day	Mode	Topics	Activities	Materials
Day 1: Understanding Technological Integration	Online	Introduction to integrating technology in instruction Case studies showcasing successful integration	Interactive presentation Group discussion in breakout rooms	Slides, case study documents, discussion forums
Day 2: Pedagogical Strategies for Technology Integration	Online	Pedagogical theories and models for technology integration Designing lessons with technology in mind	Workshop on lesson design Peer review of lesson plans	Workshop handouts, lesson plan templates
Day 3: Hands-on with Educational Technology Tools	Online	Overview of various educational technology tools Practical session on using these tools	Hands-on practice sessions	Computers/tablets, access to educational software and tools
Day 4: Developing Content with Technology	Hybrid	Content development for digital platforms Using multimedia in lesson content	Zoom by a guest speaker Group project on content development	Digital content creation tools, webinar software

Day 5: Reflection and Future Planning	Online	Reflecting on learning Planning for future technology integration in classrooms	Group discussions and presentations Feedback and closing ceremony	Reflection journals, presentation tools

Appendix 7 Class Observation Protocol: Opportunities for Teachers' TPACK Development

Observation Process:

Duration: a full class session (90 minutes)

Note-Taking: Detailed notes should be taken, focusing on the areas outlined below.

Class Observation Areas: TPACK, CK, TK, PK

Class Observation Protocol: Opportunities for Teachers' TPACK Development

1. Technology Integration in Teaching (TK)

- Observation Focus:

- Assess opportunities where teachers are using and experimenting with various educational technologies in their teaching.

- Observe how teachers select and use digital resources, tools, and platforms.

Developmental Question:

- What opportunities are being provided for teachers to enhance their skills in integrating technology into their teaching practice?

2. Deepening Subject Matter Knowledge (CK)

- Observation Focus:

- Look for instances where teachers deepen their understanding of the subject matter.

- Evaluate opportunities for professional development in their specific subject area.

- Developmental Question:

- How are teachers being supported to strengthen their content knowledge and its application in teaching?

3. Curriculum Alignment and Pedagogy (PK)

- Observation Focus:

  - Observe how teachers align their teaching with curriculum standards and objectives.

  - Assess opportunities for teachers to learn and implement various pedagogical strategies.

- Developmental Question:

  - In what ways are teachers' learning to align their teaching with curriculum standards while employing effective pedagogical strategies?

4. Exploring Diverse Teaching Strategies (PK)

- Observation Focus:

  - Evaluate opportunities for teachers to explore and refine a range of teaching strategies.

  - Observe professional development sessions or peer collaboration focused on pedagogical growth.

- Developmental Question:

  - What opportunities do teachers have to learn, experiment with, and refine diverse teaching strategies?

5. Classroom Management Skills (PK)

- Observation Focus:

  - Assess how teachers are developing skills in managing classroom dynamics.

  - Look for training, mentorship, or feedback sessions that focus on classroom management.

- Developmental Question:

  - How are teachers being facilitated to develop and enhance their classroom management skills?

6. Integrating TPACK in Lesson Design

- Observation Focus:

- Observe how teachers design lessons that integrate technology, pedagogy, and content knowledge.

- Look for planning sessions or collaborative discussions focusing on TPACK-aligned lesson design.

- Developmental Question:

- What support and resources are available for teachers to create lessons that effectively integrate TPACK components?

Appendix 8 Interview Protocol of OTL in Teacher's Experiences for TPACK Development Introduction

Confidentiality and Use of Information: Assure confidentiality and clarify how the information will be used.

Interview Questions

1. Technology Integration (TK)

a. In what ways have you evolved or changed your integrating technology into your teaching over?

b. Can you share examples of how your change result from your teaching experience?

2. Pedagogical Strategies (PK)

a. In what ways have you evolved or changed your teaching methods over time?

b. Are there development opportunities that have significantly influenced your pedagogical approach from your teaching experience?

3. Content Knowledge (CK)

a. How do you stay updated with the latest developments in your subject area? Are there any development chances from your teaching practicum?

b. Can you discuss any challenges you've faced in aligning your content knowledge with current teaching mode?

4. TPACK Framework Integration

a. Can you give some examples about challenges you've faced in integrating knowledge in delivering your content knowledge with current teaching mode?

b. Are there any opportunities to improve your ability to tackle such challenges?

5. Opportunities for Professional Growth

a. What kind of opportunities do you feel you need or would like to have for further development in your teaching practice?

b. Are there specific areas within the TPACK framework where you feel more support or training is needed?

6. Additional Insights

a. Is there anything else you would like to share about your experiences or thoughts on professional development in teaching?

Appendix 9 Interview Protocol for Administrators from TNHE Institutions

Purpose: To characterize the learning opportunities in university context with regard to TPACK development in language teaching within TNHE settings

Confidentiality and Consent: Assure confidentiality and obtain consent for recording and using the information for research purposes.

Duration: 20-30 minutes

1. Can you describe how technology is integrated from university side, for example LMS, video conference tools, collaborative tools and multimedia tools?

2. What are university overarching objectives for a language teaching during COVID-19? How do you see technology enhancing these goals?

3. What resources or materials do university supply for language teaching, specifically those that integrate technology, pedagogy, and content knowledge (TPACK)?

    a. How do access to these TPACK resources influence teachers' language teaching? Are there additional resources within the university that assist in TPACK development, or are there resources you feel are lacking?

    b. Do language instructors collaborate or share practices with these recourses? If so, how is this collaboration structured?

4. How do you perceive the value of integrating TPACK in language instruction compared to traditional methods?

    a. What benefits do students gain from TPACK-informed language learning?

    b. How does TPACK integration align with broader educational goals at your institution?

5. Is there any additional information you can provide about the promotion, challenges, or successes of TPACK development in language teaching within your university's context?

Thank the Participant: Acknowledge their time and valuable contributions.

Appendix 10 Interview Protocol for Instructors: Opportunities in TPACK Development

Introduction

Purpose: Explain the goal of the interview is to gather insights into the opportunities and support provided by the university for TPACK development.

Confidentiality and Consent: Assure confidentiality and obtain consent for recording and using the information for research purposes.

Duration 20-30 minutes

Interview Questions

1. Background and Experience in TPACK

    a. Can you briefly describe your teaching background and your familiarity with the TPACK framework?

2. University-Supported Development Opportunities

    a. What kind of professional development opportunities do the university provide for enhancing skills in technology integration, pedagogy, and content knowledge?

    b. How accessible and effective do you find these opportunities?

3. Technology Integration Experience (TK)

    a. Can you share some examples of how you have integrated technology into your teaching?

    b. What challenges have you faced in using technology, and how has the university supported you in addressing these challenges?

4. Pedagogical Strategies and Support (PK)

    a. How does the university support your development in adopting diverse and effective pedagogical strategies?

b. Are there specific programs or resources provided by the university that have influenced your teaching approach?

5. Content Knowledge Enhancement (CK)

a. In what ways does the university facilitate your continuous learning and staying updated in your subject area?

b. How do these initiatives impact your content delivery in the classroom?

6. Integration of TPACK Components

a How do you perceive the integration of technology, pedagogy, and content knowledge in your current teaching practice?

b. What support or resources does the university offer to help you effectively combine these elements?

7. Feedback and Reflection

a. How does the university gather feedback from instructors about professional development programs?

b. Are there opportunities for reflective practice or sharing experiences with peers regarding TPACK development?

8. Challenges and Recommendations

a. What improvements or additional support would you recommend to the university for enhancing TPACK development?

10. Additional Comments

a. Is there anything else you would like to add that we haven't covered, especially regarding TPACK development support at the university?

Thank the Participant: Acknowledge their time and valuable contributions.

Appendix 11 Codebook for opportunity to learn in TPACK and its domains

Opportunities that support instructors' knowledge of how to…	Code	Description	CPD (PPT slides)	CPD (Teaching plan)	Practice (class observation) participant	Practice (interview with participants)	University context (intervein with administrators)	University context (intervein with participants)
Tearning technologies integration	TK-TechIntegration	Opportunities that support teachers' knowledge of how to integrate and apply various educational technologies to enhance learning.						
Digital Resource Utilization	TK-DigitalResources	Opportunities to learn the selection and use of digital resources, tools, and platforms for effective instruction.						
Subject Matter Expertise Development	CK-Expertise	Opportunities to deepen understanding of the subject matter, ensuring a strong foundational knowledge base for teaching.						
Curriculum Content Alignment	CK-Alignment	Opportunities to learn how to align teaching with the curriculum standards and objectives.						
Instructional Strategies Enhancement	PK-Strategies	Opportunities to learn and refine a range of teaching strategies to engage students effectively.						
Classroom Management Skills	PK-ClassroomManagement	Opportunities to develop skills for managing classroom dynamics and promoting a positive learning environment.						
Integrative Approach to Technology and Content	TPACK-Integration	Opportunities that combine technology and content knowledge to create engaging and meaningful						

		learning experiences.
Designing Technology-Enhanced Lessons	TPACK-Lesson Design	Opportunities to design lessons that thoughtfully integrate technology in ways that complement and enhance the subject content.