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Driving Factors and Constraints Influencing Primary School Teachers' TPACK Development in Hybrid Communities of Practice in South Africa

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Abstract. Despite the growing emphasis on TPACK as an important knowledge, many South African primary school teachers lack structured support to integrate technology effectively into teaching. This study explores the driving factors and constraints influencing primary school teachers' development of Technological Pedagogical and Content Knowledge (TPACK) within hybrid Communities of Practice (CoPs) in South Africa. The research is grounded in Wenger's (1998) CoP social learning theory and Mishra and Koehler's (2006) TPACK model. A qualitative research approach was employed, involving a group of 12 purposefully selected teachers who participated in open-ended survey questionnaires, one-on-one semi-structured interviews, observational sessions, and in WhatsApp group chat screenshots, all of which were analysed through Atlas.ti. The findings showed the key elements outlined by Wenger (1998) in his CoP social learning theory emerged as key motivating factors for teachers' acquisition of TK, PK, CK, and TPK. These key elements include community, shaped by social arrangements; practice, defined by problem-solving strategies; meaning, reinforced through repeated dialogues; and identity, enriched by the interaction of core members and newcomers. Conversely, community also acted as a constraint, as teachers' personal characteristics and traits limited the acquisition and sharing of TK, TPK, TCK, and TPACK within their hybrid CoPs. Gaining an understanding of the relationships between specific factors and their varying effects on TPACK development may offer more focused insights for policymakers, including national governments and

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global organisations, such as the Commonwealth of Learning (COL) and, the United Nations International Children's Emergency Fund (UNICEF).

Keywords: Constraints; Driving factors; Hybrid Communities of Practice; Primary Schools; Teachers; TPACK; teacher professional development

1. Introduction

Despite widespread acknowledgement among scholars of technology's significant role in enhancing teaching and learning, many teachers lack proficiency in both technology and pedagogy (Graham, Stols & Kap, 2020; Mahlo et al., 2024). This, coupled with inadequate professional development programmes which focus on technological integration, has resulted in these technologies being frequently overlooked, resisted, or under-utilised (Mahlo and Waghid, 2025). Enhancing teachers' technological proficiency is crucial for the effective integration of technology, pedagogy, and content as delineated in the TPACK framework (Mishra & Koehler, 2006), particularly as recent studies show educators' increasing experimentation with generative AI tools like ChatGPT to support classroom instruction and reflective practice (Ampo et al., 2025).

This proficiency may be inherently facilitated through participation in CoPs, where collective learning cultivates confidence and competence in using digital tools (Tyarakanita et al., 2021). Amemasor et al. (2025) strengthens this argument by stressing that Teacher Professional Development (TPD) encompasses all forms of ongoing professional education for educators, including training, seminars, coaching, CoPs, and self-directed learning. Amemasor et al. (2025) asserts that high-quality TPD may enhance classroom teaching practices by directly affecting teacher-related outcomes, including topic understanding, digital competencies, and pedagogical methods.

This research posits that the poor quality of TPD programmes, globally (Amemasor et al., 2025) is the primary obstacle to teachers' effective integration of technology in their pedagogical practices, especially in low resource contexts such as those in most of the African countries (Amemasor et al., 2025)), and South Africa is no exception (Tiba & Condy, 2021). This clearly suggests that the low quality of TPD programmes, further exacerbated by limited or absent Information and Communication Technology (ICT) resources, can result in inadequate and irrelevant digital skills, particularly those that do not align with the TPACK framework.

Numerous scholars have identified specific factors that hinder schoolteachers from learning and using technology effectively and appropriately (Mhlongo et al., 2023; Mwapwele et al., 2019; Timotheou et al., 2023). These include ineffective policymaking and enforcement by schools and education departments, a lack of institutional support, historical inequities such as apartheid policies, underqualified teachers, and uneven resource allocation in certain regions of South Africa (Hart, 2023; Dlamini & Mbatha, 2018). Some teachers resisted change, further complicating the situation (Mwapwele et al., 2019; Spiteri & Rundgren, 2020).

These factors affect the acquisition and dissemination of information and knowledge within CoPs. They also increase teachers' dependence on CoPs as a principal source for obtaining the knowledge essential for the effective integration of technological resources into their pedagogical practices, rather than relying on government-funded training programmes (Mahlo et al., 2024; Wang, 2020; Yildirim, 2008). While certain factors may hinder teachers from learning important knowledge from one another, research also highlights that specific elements within a CoP can actively facilitate and enhance members' learning (Xu & Ko, 2019; Dube et al., 2018).

School-based structures, such as ICT committees (Vanderlinde, Dexter & Van Braak, 2011) and informal meetings (Cotter, Leahy, McManus, Oldham & O'Sullivan, 2017) are found to promote repeated dialogues and collaboration, helping build teacher confidence and a sense of belonging (Patton & Parker, 2017). Shared problem-solving strategies further encourage TPACK-related learning (Batchelor, 2020; Holland, 2018), while knowledgeable newcomers can positively influence more experienced teachers' integration of technology (Phillips, 2014).

Consequently, several scholars (Batchelor, 2020; Cojorn, 2024; Cotter et al., 2017; Dube et al., 2018; Holland, 2018; Karathanos-Aguilar & Ervin-Kassab, 2022; Phillips, 2014; Xu & Ko, 2019) contend that, although CoPs can evolve organically or purposefully to facilitate members' acquisition of significant knowledge from one another, certain factors may either enable or hinder this process. Wenger (2011) characterises CoPs as collectives of individuals who share a common interest or enthusiasm for a particular activity and enhance their proficiency through regular interaction.

Wenger (2011) further states that these groups primarily convene in person, while others predominantly engage online, and that some are officially acknowledged and frequently backed by a budget. In contrast, others are entirely informal and may even go unnoticed. Brooks (2010) and Byington (2011) observe that some communities may assemble through a blend of in-person and digital contacts, occurring both simultaneously and at different times, a strategy recognised as a hybrid CoP technique (Sumandiyar et al., 2021). This methodology was chosen for the present research because of its intrinsic adaptability.

Hybrid CoPs have gained prominence in education, especially during the COVID-19 pandemic and subsequent lockdowns. However, there appears to be a lack of research identifying the driving factors and constraints associated with hybrid CoPs in the development of primary school teachers' TPACK in South African schools. One exception is Dlamini et al. (2024) who examined the efficacy of CoPs in the professional development of teachers in technical disciplines within selected South African schools. While Xu and Ko (2019) highlight structured CoPs as motivators in China, South African studies (Mahlo et al., 2024) reveal that hybrid CoPs often evolve informally due to ICT infrastructure gaps.

Nonetheless, none of this research investigated the characteristics that might either promote or impede teachers' successful acquiring of critical knowledge and skills within these hybrid CoPs. Comprehending the correlations among various components and their varying effects on TPACK might provide more focused insights for policymakers in South Africa and in other similar contexts around the globe in their efforts to assist primary school teachers in the successful and meaningful integration of technology for curriculum delivery.

Moreover, beyond policymakers, stakeholders such as curriculum designers, school principals and researchers play key roles in enhancing teachers' TPACK development. However, there remains an empirical gap in understanding the specific ways in which hybrid CoPs can and do foster teachers' technology integration skills in under-resourced South African contexts. We contend that further research is needed to identify which factors influence TPACK development within hybrid CoPs, and to explain why these factors have differing impacts.

In response to the identified research gap, the following research question initiated the formulation of this paper:
1. What are the driving factors and constraints influencing primary school teachers' TPACK development in hybrid CoPs?

2. Contextual factors influencing teachers' collaborative learning of technological knowledge for pedagogical application.

Prior research indicates that certain factors within a CoP are beneficial in facilitating teachers' acquisition of useful knowledge from their peers. Xu and Ko (2019) discovered that structuring scheduled meetings among teachers, such as those for lesson preparation and final assessment sessions, by means of reciprocal learning, acted as a motivational factor for teachers to share knowledge within their CoPs in some schools in Hong Kong, China. In their study conducted in Cork, Ireland, Cotter et al. (2017) emphasised the opportunity for teachers to participate in ongoing discussions when using informal group meetings.

These provided a forum to address the duties of members, their difficulties, and collaborative possibilities in a casual and low-pressure setting. Teachers may learn organically from one other in their CoPs during these casual get-togethers. According to Patton and Parker (2017), when colleagues engage in discussions, this can help reduce isolation. This, in turn, can lead to members' stronger sense of confidence and belonging to a community. ultimately, helping colleagues recognise their own potential to become better teachers. To illustrate the importance of belonging to a learning community, Güngördü and Yıldırım (2025) performed research in Turkey on Mathematics teachers developing their knowledge in the use of technology for curriculum delivery inside an in-service CoP.

These authors demonstrated that, amongst the participating Mathematics teacher's confidence functioned as both a result and an advancement of the learning process, enabling these teachers to evolve from basic, traditional

Mathematics teachers to proficient and self-assured teachers, adept at using technology in their classrooms. In their study, conducted in Canada, Massie et al. (2022) assert that belonging to a community encompasses the power to enhance teachers' transformative practices and creativity. These behaviours include identity formation, relationship cultivation, and the establishment of social structures. In an educational setting, a social structure may include a committee expressly focused on ICT issues inside the school. This notion corresponds with the results drawn by Razzak (2015) from his research on the integration of ICT in educational settings in Bahrain. Razzak (2015) argues that teachers' successful use of digital technologies in teaching requires the creation of support structures that enhance their ICT competency and confidence.

Similarly, Hennessy et al., (2022) assert the crucial importance of establishing support structures that enable teachers to augment their technological skills and confidence in low-and middle-income countries. As a result, Vanderlinde et al. (2011) pointed out, teachers' confidence and the presence of an ICT committee in schools may significantly impact teachers' ability to gain important knowledge from their CoPs. These studies suggest the degree to which teachers are willing to share and receive feedback from one another is influenced by their level of self-confidence.

Teachers' practice of problem-solving techniques may motivate them to acquire TPACK-related knowledge. For example, using the social learning theory of CoPs, Batchelor (2020), Cojorn (2024), and Cotter et al. (2017) noted that members of CoPs participated in concept exploration, contextual discussions, and collaborative problem-solving. In addition, according to Cojorn (2024) and Holland (2018), a powerful CoP is defined by its members' ability to work together to solve problems and overcome obstacles associated with practice.

Stănescu, Andronache, and Böhmer (2022) assert that to settle a dispute among group members, both parties need to directly address the problem and seek dialogue with the opposite side. The perspectives mentioned above lead one to conclude that practices are knowledge-meaning-infused patterns of socially recognised behaviours. These practices shape people's lives and are profoundly ingrained in communities, routines, and organisations (Graeger, 2016). Wenger (1998, p. 53) contends that people are in a constant process of negotiating meanings.

According to Wenger (1998), the negotiation of meaning involves ongoing processes of language use, consensus building, and task performance all of which require constant adaptation. In alignment with this view, Tulloch et al. (2025) argue that professional learning grounded in Indigenous language use enhances teachers' contextual understanding and strengthens their professional agency. He (Wenger, 1998) perceives CoPs as characterised by a continuous process of meaning negotiation, in which members undertake to understand and attribute value to their shared experiences collectively (Wenger, 1998).

To elucidate the significance of meaning negotiation, teachers, while possessing an intimate familiarity with their colleagues within a school setting, persist in engaging in ongoing discussions. Although their actions and words may reference earlier events, they generate a whole novel context, accompanied by fresh thoughts and experiences. In a study conducted in Romania and Germany. Stănescu et al. (2022) argue that communication serves as the fundamental basis for forming relationships and organising societies, achieved through the negotiation of meaning.

The literature supports the idea that the CoP social learning theory works best when group members meet together often enough to facilitate the process of ongoing meanings through recurrent conversations. Thus, Magnusson and Godhe (2019), along with Rani et al. (2023), highlight that digital technology has facilitated the blending of resources, thereby streamlining and supporting the continuous process of meaning-making across different modalities and media, which in turn offers essential support to members of a hybrid CoP.

Phillips (2016) further explains that their evolving identity and professional practice influence the development of teachers' TPACK within CoPs. Spanellis and Pyrko (2021) expand on the idea of how people form their identities through belonging to a CoP, arguing that this process begins when people learn to associate their own characteristics and traits with the CoP to which they belong, building on the work of Farnsworth et al., (2016).

However, teachers' individual identities may get in the way of their TPACK learning. One example of a barrier to acquiring important knowledge and abilities is their unwillingness to change and, linked to this, unfavourable attitudes towards employing technology in the classroom (Mathipa & Mukhari 2014). Guo and Wang (2024) and Mathipa and Mukhari (2014) point out that some teachers are hesitant to use technology in the classroom due to the belief that it assists neither their learners nor themselves. Nikolopoulou et al., (2023), along with Umugiraneza et al. (2018), view resistance to change as a trait hindering the development of teachers' competence. This resistance may lead to teachers struggling to establish a sense of identity as core members of their CoP.

Other teachers may find greater motivation to successfully incorporate technology into their lessons if more seasoned teachers are available, who are well-versed in the use of technology in the classroom. To back up this claim, Phillips (2014) defines a CoP as an ever-changing setting where newcomers have access both to seasoned members' knowledge and a unique participatory experience to help integrate what they have learned into who they are as contributing members of the community.

In contrast, Baya'a et al. (2019) emphasise that, while novice or newly appointed teachers may have limited classroom experience, they often exhibit enhanced skills in using technology for teaching. This suggests that newly appointed teachers in schools do not solely function as mentees; they may also act as resources, seasoned users of technology in teaching, offering mentorship to more

experienced teachers. Upon entering schools, they can immediately enhance the professional and indivieual identities of veteran teachers. This is supported by LoBuono et al. (2020) who argue that reverse mentoring, younger adults providing support and knowledge to older adults, can be a vehicle for teaching technology.

3. Theoretical Frameworks

3.1. CoP social learning theory (Wenger, 1998)

Wenger (1998) identifies four basic components of learning inherent in a CoP. These components include, firstly, community, which entails learning through a feeling of belonging. A community is a social structure defined by people's actions and recognition of their competency in participation (Wenger, 1998). Secondly, practice entails learning as experience. Wenger (2011, p. 2) asserts that communities develop their practices through a variety of activities, including problem-solving, information-seeking, asset utilisation, coordination and synergy, discussions on advancements, documentation efforts, site visits, knowledge mapping, and gap identification. Third is meaning, which entails acquiring knowledge via experience. Wenger (1998) asserts that people's engagement in a certain activity may display distinct patterns, yet the process of forming these patterns engenders a feeling of meaning.

Fourth is identity, which encompasses the process of learning through becoming. Wenger (1998) asserts that the concept of "identity" facilitates a sociological examination of an individual's status, including, as noted by Lave and Wenger (1991), of peripheral members or veterans within a CoP. The notion of legitimate peripheral involvement, articulated by Lave and Wenger (1991), is easily applicable to novice and inexperienced teachers entering an established CoP, including teachers with diverse competence levels. Wenger (1998) contends that the process of identity formation in learning includes the nurturing and enhancement of individual characteristics and traits. The theoretical framework methodologically explores the convergence of various learning components, providing a foundation for analysing learning as a mode of social engagement (Wenger, 1998).

3.2. TPACK model

We used the TPACK model developed by Mishra and Koehler (2005) as a framework additional to the CoP social learning theory to elucidate the distinct categories of knowledge that primary school teachers acquire and disseminate within their hybrid CoPs. The approach delineates four areas of knowledge that intersect with three knowledge domains—content, pedagogy, and technology, culminating in seven knowledge domains.

Technological Knowledge (TK) includes knowledge of conventional and contemporary media and signifies the comprehension and recognition of technological skills (Koehler & Mishra 2012; Mishra & Koehler 2006). Pedagogical Knowledge (PK) encompasses a broad comprehension of instructional methodologies, methods, and approaches, integrating broader educational goals

(Mishra & Koehler 2006). Koehler et al. (2014). Content Knowledge (CK) refers to the essential understanding of disciplines, excluding the pedagogical dimension. Technological Pedagogical Knowledge (TPK) encompasses the comprehension of employing technology proficiently and purposefully to enhance particular pedagogical methodologies (Koehler et al., 2014). Pedagogical Content Knowledge (PCK) pertains to the transformation of subject matter knowledge and expertise into effective instructional strategies, and the establishment of supportive learning environments (Mishra & Koehler, 2005; 2006).

According to Koehler and Mishra (2008), Technological Content Knowledge (TCK) is more comprehensively defined as an awareness of the dynamic relationship between technology and content, as well as an understanding of the technologies suitable for different subject areas. TPACK necessitates teachers supporting learners in acquiring subject matter knowledge by employing specific pedagogical strategies alongside integration of appropriate technological tools (Koehler & Mishra, 2012). This framework serves as the basis for effective and meaningful technology integration in educational settings.

3.3. Contextualising the TPACK Framework through Communities of Practice

Although Mishra and Koehler (2006) do not explicitly discuss context as an intersecting element, their model implies that the setting in which teachers acquire and apply knowledge plays a central role in connecting the different TPACK domains. Thus, using the TPACK model without consideration of context would be inadequate for fulfilling this study's objective: to understand the driving factors and constraints influencing primary school teachers' TPACK development in hybrid CoPs.

Wang (2020) emphasises a CoP offering a context for educators to interact and support one another in the successful integration of technology into their pedagogical approaches. Phillips (2014) posited that workplace learning theories, particularly those similar to theories pertaining to CoPs, provide a unique context for understanding the evolution of educators' TPACK. Phillips (2014; 2016) and Wenger (1998) assert that a CoP serves as an appropriate framework for contextual learning. Tyarakanita et al. (2021) performed research on a WhatsApp-based online CoP using Wenger's (1998) CoP and TPACK models and discovered that the growth of teachers' TPACK had been influenced by CoPs.

Mishra and Koehler (2006) acknowledge the influence of context on the development of teachers' TPACK; however, they fail to elucidate how an environment within which a CoP operates can be defined as a context, nor do they specify the socio economic, infrastructural etc. factors that may act as motivators or constraints to a community's capacity for augmenting the TPACK of teachers, We utilised the CoP framework developed by Wenger (1998) as the primary framework to investigate the context in which TPACK could be cultivated to address this disparity.

4. Methodology

4.1. Research approach

This study employs a qualitative research approach grounded in an interpretivist paradigm. A multiple case study research design was used to obtain a deeper understanding of practices individuals use to address situations and how various issues may influence behaviours across several domains (Compton-Lilly, 2012). Participants provided their informed consent by filling out and submitting a consent form. Out of a population of 95 teachers, 12 were purposefully chosen to constitute the sample. The study aimed to purposively select participants from the overall population based on their open-ended survey questionnaire responses, from responses indicating collaboration with colleagues in using technology for curriculum delivery.

A self-administered open-ended survey questionnaire, with two questions, was sent to 95 teachers to identify and recruit interested and appropriate participants for the sample. The survey questionnaire questions were, (a) Apart from workshops organized by the WCED, how did you acquire your technological skills for teaching and learning?', (b) Would you agree that at your school all teachers are united and work as a team? Please elaborate. Although the primary purpose of the survey questionnaires was to recruit participants from the school populations, the limited data obtained through this method were also subjected to analysis. Out of the teachers who completed and submitted the open-ended survey questionnaires, nine were from School A, eight from School B, and ten from School C, resulting in a total of 27 respondents, hence only 12 were purposefully chosen from the 27.

However, four teachers were selected from each school. . These teachers were chosen because their survey questionnaire responses indicated active collaboration within their schools around using technology for teaching and learning, demonstrating the presence of a CoP. In order to safeguard their privacy, teachers are labelled as Teachers A, B, C, D, E, F, G, H, I, J, K, and L. All 12 participating teachers participated in individual semi-structured interview sessions; all teachers from the three schools were notified about the planned observations of their meetings and provided their consent. The observations were conducted between 3 April and 21 April 2023, with approximately one week spent at each school. Semi-structured interviews were conducted to acquire a deeper understanding of nature and extent of the influence of hybrid CoPs on the development of the selected public primary school in-service teachers' TPACK.

Teachers were informed that screenshots from staff WhatsApp group chats would be analysed. With principals' permission from the three schools, we sought relevant WhatsApp screenshots covering up to a year before data collection in early March of 2023. However, the screenshots provided by a volunteer teacher at each school, shared privately, dated back less than three months. The self-administered open-ended survey questionnaires, interview questions, observation protocol, together with the selected information for analysis from WhatsApp group chats used in this study were guided by the CoP social learning theory and the TPACK model, which together formed the theoretical frameworks

for this research. All tools were expert-validated by another scholar and pilot-tested for clarity before use.

Survey questions were informed by the CoP social learning theory, focusing specifically on mutual engagement to explore whether collaboration, formal or informal, existed among participant teachers. The analysis examined whether the teachers' responses reflected any of the four components of the CoP social learning theory; community, identity, practice, and meaning, which could act either as enablers of, or constraints to, their acquiring TPACK-related knowledge. The interview questions drew on both the CoP theory and the TPACK framework. The four key components of COP theory were used to identify factors that could either support or hinder teachers' ability to learn TPACK within their hybrid CoPs.

The TPACK framework helped examine the specific types of knowledge (TK, CK, PK, TPK, TCK, PCK, and TPACK) the participating teachers might acquire, or be restricted from accessing, The interview questions:

1. Do teachers collaborate at your school?
2. What motivates you to use online tools to share information with your teachers?
3. What discourages you from using online tools to share information with your immediate colleagues?
4. What technological tools do you use to share or communicate information with other teachers? /What platforms does the school use to communicate important matters with staff and what kind of information is mostly shared?
5. Would you say that you are able to use these online tools effectively to share teaching strategies? If yes or no, please elaborate.
6. Why do you use these particular tools?
7. Do you think these technological tools are helpful? If so or if not, why?
8. How do you acquire new technological skills necessary for your teaching?
9. Do you share technological teaching and learning tools and knowledge with your colleagues? How and when do you share these resources?
10. What kind of information do you share?

The interview questions aimed to capture comprehensive data across all domains of the TPACK framework. Although they may appear to focus primarily on technological knowledge (TK), this was not the intention. We were aware that teachers' responses would naturally reflect elements of other TPACK domains. The questions were therefore structured in a straightforward manner to ensure that participants could respond comfortably without being burdened by technical distinctions among the TPACK components.

By framing the questions using familiar terms, such as "technology," we aimed to elicit authentic and contextually grounded responses that could later be interpreted across the full range of TPACK domains. The four CoP components also shaped the observation protocol, particularly in analyzing staff meetings for verbal and non-verbal indicators that aligned with any of the components. Lastly, both the CoP and TPACK frameworks guided the analysis of WhatsApp group chat screenshots. The chats themselves served as evidence of hybrid CoPs, while

the analysis aimed to identify types of knowledge exchanged, particularly in relation to TPACK domains. We recognized that WhatsApp group chats are often used for a variety of communications, with limited discussion directly related to TPACK. For this reason, the data obtained from WhatsApp screenshots were not used to draw conclusions but rather to supplement insights gathered from other data sources, including one-on-one semi-structured interviews, observations, and survey questionnaires.

The isiXhosa content was translated by one researcher, who is fluent in isiXhosa and grew up in Khayelitsha, the study area, and verified through back-translation to ensure accuracy and consistency. All data were analysed using ATLAS.ti following Creswell and Guetterman's (2019, p. 241) systematic steps. The process involved organising and uploading all data files into the software, coding relevant text segments, and grouping related codes into broader themes supported by evidence.

4.2. Study context

This research was conducted in three purposefully selected public primary schools in the Western Cape province of South Africa. Given the research question and design, purposive sampling was deemed appropriate for selecting schools, focusing on participants with relevant experience in TPACK development through hybrid CoPs. The sample was not intended to represent the wider population but was chosen for its relevance, simplicity, and efficiency. We refer to these as Schools A, B, and C to maintain confidentiality.

All 12 teachers who participated in this study were responsible for teaching grades 3 to 6 in subjects including IsiXhosa Home Language (HL), Mathematics, and English First Additional Language (FAL), subjects being the primary focus of most ICT initiatives in Western Cape schools. The data were analysed using ATLAS.ti, a computer-assisted qualitative data analysis software, following Creswell and Guetterman's (2019, p. 241) systematic procedures. The Khanya Project, Green Shoots, Click Foundation, and the Game Changer, four notable ICT initiatives implemented by the Western Cape Government (WCG) seem to have favourably influenced all three schools in the historically marginalised township of Khayelitsha.

The three schools are classified as quintile 3 schools, which receive substantial financial support from the South African government, similar to quintiles 1 and 2 schools. In the South African context, schools are divided into five quintiles according to their proximity to economically disadvantaged communities. This system serves as a governmental tool to identify and support under-resourced schools (Ogbonnaya & Awuah, 2019). This means governments fully subsidises schools in Quintiles 1 to 3, those considered to be the most economically disadvantaged. In contrast, Quintile 4 and 5 schools, typically located in more affluent urban and suburban areas, are regarded as economically advantaged (Ogbonnaya & Awuah, 2019).

School A accommodates approximately 1,100 learners with 31 teachers, School B has 979 learners and 29 teachers, while School C serves 1,700 learners with 38 teachers. In the past two years, all three schools have maintained a pass rate exceeding 90%. These schools were chosen due to their relatively advanced ICT resources within Khayelitsha and their participation in the Westen Cape G's TPD initiatives.

5. Findings

5.1. The driving factors influencing primary school teachers' TPACK development in hybrid CoPs

Table 1outlines the motivating factors that enable teachers' learning of TPACK-related knowledge within hybrid CoPs, specifically those teachers and their respective schools who indicated some colleagues may be motivated to learn TPACK-related skills in their hybrid CoPs. Blank cells indicate no evidence of the constraint was found for that teacher/school/component.

Table 1: Motivating factors towards TPACK development in hybrid CoPs

Schools	Teachers	Data collection tools	Community	Practice	Meaning	Identity
			Social arrangement	Problem-solving strategies	Repeated dialogue	Core members and Newcomers
A	A	Questionnaires				PK
		Interviews		TK, PK,		
	B	Questionnaires				
		Interviews				
	C	Questionnaires				
		Interviews	TK	TPK		
	D	Questionnaires				
		Interviews			CK	
		Observation				
		WhatsApp texts	TK			
B	E	Questionnaires				
		Interviews				
	F	Questionnaires				TK
		Interviews		TPK		
	G	Questionnaires				
		Interviews	TK			
	H	Questionnaires				
		Interviews				
		Observation				
		WhatsApp texts				
	I	Questionnaires				
		Interviews				
	J	Questionnaires				
		Interviews				

C	K	Questionnaires				
		Interviews			CK	
	L	Questionnaires				
		Interviews				
		Observations			TK, TPK	
		WhatsApp texts	TK			

5.1.1. Community (learning through a sense of belonging)

In the present study, social arrangements as a significant sub-theme connected to the concept of community emerged from teachers' interview responses. This sub-theme was subsequently used to describe the theme of community.

- *Social arrangement*

Wenger (1998) defines a community as a social structure characterised by the acknowledgement of its members' competencies in participation and the specification of their efforts. Teachers included in this research endorsed the ICT committees to function as social structures within their schools. They saw the committees as essential support mechanisms available to teachers needing help integrating technology in their classrooms. When asked during the interview, "*How do you acquire new technological skills necessary for your teaching?*" Three (C, G, and L) of the twelve participating teachers highlighted in their interview responses the supporting roles of their various ICT committees, as can be seen in the selected teachers' comments:

Teacher C at School A:

> *"I think at the school, like in the ICT committee... we do have people who have knowledge in connection with technology."*

Teacher G at School B:

> *"... And there also those who are in the ICT Committee that I can also go to whenever I need information."*

Teachers C and G from Schools A and B, respectively, remarked that the existence of school-based ICT committees, comprising members like the school management team (SMT) and teachers, fostered a sense of belonging among teachers. The objective of these committees, as implied by Teachers C and G, is to provide support to teachers in their use of diverse technologies. According to the remarks of these teachers, this specific element of the community (Table 1 above) could be assumed to incentivise teachers to further their TK development.

This corroborates the findings of Hennessy et al. (2022) and Razzak (2015), on the need to establish support structures that enable individuals to augment their technology skills and confidence. Although Teacher L's responses align with the aspect of social arrangement, he did not mention or suggest anything related to any of the TPACK knowledge domains. An analysis of the WhatsApp screenshots (see Figures 1 and 2 below) reinforces the teachers' comments by illustrating the role and functioning of ICT committees within schools.

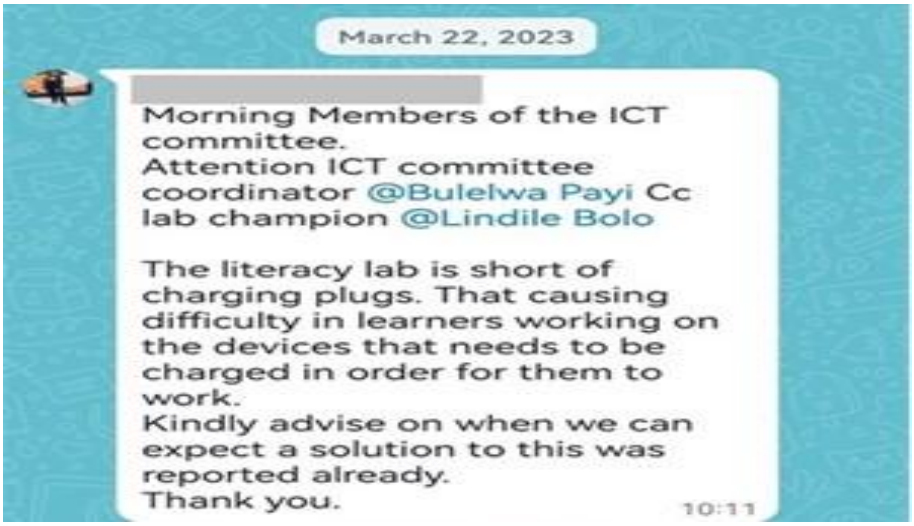

Figure 1: WhatsApp screenshot at School A

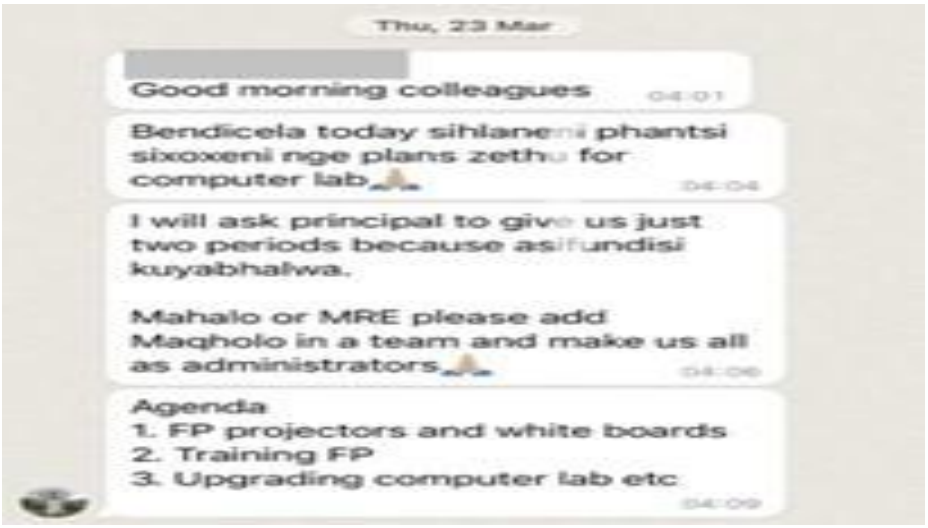

Figure 2: WhatsApp screenshot at School C

Figures 1 and 2 corroborate Teachers C and G's remarks. Specifically, Figure 1 illustrates a discussion among the ICT committee members over technological equipment, including charging plugs for tablets and laptops. This debate, as indicated in Table 1, is relevant to in-service teachers' acquisition of TK. Figure 2 presents a notification composed in the IsiXhosa language, one of South Africa's official languages, articulating a request for a meeting to discuss arrangements for a computer laboratory. The teacher's communication outlines an agenda that explicitly addresses the use of technological equipment and the need for educator training in technology applications.

Since Figure 2 does not explicitly specify the type of knowledge teachers may share during the planned training, it is reasonable to infer that they are likely to acquire TK during the training, given the established practice of integrating technology into curriculum delivery. The WhatsApp screenshots from the two

schools corroborate the interview findings, highlighting the most commonly acquired type of knowledge through the community aspect of hybrid CoPs is TK. The WhatsApp screenshots from these schools, together with teachers' interview responses, illustrate the proactive engagement of school-based ICT committees despite the potential lack of formal ICT policy in these schools. Furthermore, the employment of both WhatsApp and in-person interactions highlight the significance of hybrid CoPs within schools.

5.1.2. Teachers' practice (learning through doing)

Lave and Wenger (1991) see participation in a CoP entails active involvement in the community's socialisation process. This process enables people to progressively assimilate the community's language, norms, and practices. The problem-solving strategies used by teachers thus surfaced as a sub-theme.

- *Teachers' problem-solving strategies*

Cojorn (2024) and Holland (2018) describe a healthy CoP as one in which members participate in collaborative activities to develop problem-solving techniques and to effectively address practice-related challenges collectively. The teachers mentioned that they sometimes conversed with their peers to discuss matters related to the use of technology in education. To the interview question, "*Do teachers collaborate at the school?*", four (A, C, D, and F) out of the twelve participating teachers (refer to Table 1) explicitly remarked on problem-solving strategies:

Teacher A at School A:

> "*We do. We talk a lot about those strategies to help the learners. Even those strategies that will be helpful to us as well. Because if you notice, most teachers that are in the schools are the teachers that got their education a long time ago. And it's imperative for us to talk about these things. They don't have any idea and are not familiar with many technologically related things. So, we have an obligation to talk and share the ways as to how a person can have technological skills.*"

Teacher C at School A:

> "*I would like to believe so because teachers are not just colleagues but friends as well, they talk about almost everything even on how to teach using an ICT tool...*"

Teacher F at School B:

> "*Yes, sometimes we do. For example, I don't remember when, but when the school received the Smart Classrooms, I went to ask a colleague of mine on how to teach using this thing, a Visualizer…*"

Teacher A explicitly stated that she engaged in discussions with colleagues to address challenges and develop solutions for helping teachers acquire technological skills. Her comment indicates the significant insights acquired by teachers from their technology-oriented discussions constitute TK (Table 1). Furthermore, Teacher A reported that they sometimes participated in talks and tried to address matters related to their teaching techniques. Thus, as articulated

by Teacher A, PK (as seen in Table 1) is an essential body of knowledge teachers may acquire via sharing problem-solving methodologies inside their schools. Teacher (A) said their main contacts were with all teachers: some teachers lack proficiency in technology integration due to their having graduated many years before. The responses of Teachers C and F show similarities in that both highlight informal collaboration among colleagues in the use of technology in teaching.

Specifically, Teacher F mentioned seeking assistance from other teachers when using a new tool in the classroom. These reflections suggest TPK (Table 1) is a form of knowledge commonly shared among teachers in these schools. Although Teacher D's responses align with the aspect of problem-solving strategies, she did not mention or imply anything related to any of the TPACK knowledge domains.

5.1.3. Teachers' meanings (learning through experience)

One subtheme that emerged from the interviews t and teachers' meeting observations was the use of repeated dialogues, which teachers indicated they rely on to interpret meanings.

- *Repeated dialogues*

Within a school setting, teachers may possess an intimate familiarity with their colleagues, but persist in engaging in ongoing scheduled, topic related discussions. Although their statements and actions may reference prior events, they always culminate in an entirely new situation, set of feelings, and experience. Wenger (1998) elucidates this tendency, which accounts for how individuals' meaning-making processes either extend, divert, reject, reinterpret, modify, or confirm their associated meaning-history. In answer to "*What platforms does the school use to communicate important matters with staff and what kind of information is mostly shared?*", three of the twelve participant teachers (D, E, and K) from the three schools (A, B, and C) reported tconducting scheduled brief meetings on specific days of the week to discuss matters pertinent to their practice:

Teacher D at School A:

> "*When there is an information related to the curriculum or any other matters affecting learners or teachers, that the principal needs to share, there are briefings that we hold on Tuesdays and Thursdays. The information is shared during these briefings. Then if it's something urgent like on a Monday, there is a WhatsApp group for schoolteachers. So, the principal or deputy shares the information there when he can't meet the people face-to-face.*"

Teacher E, at School B:

> "*… So even if we are in the staff room for meetings and briefings and stuff, I always go there first and then give them briefings before the management comes and do briefings. So yeah, I'm connected to all the teachers.*"

Teacher K at School C:

> "*… Sometimes we even hold meetings through that WhatsApp group when we don't have time where we share teaching content related to one's subject*."

The responses of Teachers D and K regarding the sharing of curriculum-related matters suggest that CK (Table 1) is one of the types of information exchanged during brief morning meetings at Schools A and C. While Teacher E's response aligns with the aspect of repeated dialogue, it does not mention or imply any connection to the TPACK knowledge domains. The morning briefings at schools appeared to provide a useful forum for teachers to create and negotiate meanings since these discussions are consistently scheduled on designated days of the week.

Consequently, there is a probability that topics addressed in previous brief meetings may be revisited in subsequent meetings, maybe with the inclusion of further concerns or information. According to Teacher D's comment above, the individual leading the meeting (usually the principal) frequently shares and/or reminds teachers about issues relevant to their practice. Teachers are also given the opportunity to raise concerns or offer feedback about their practice during these morning briefings.

This was further observed during the following brief meeting at School C. Teachers at this school primarily discussed the same topics as they had in the previous brief meeting. These included the efficient use of teaching and learning time by teachers and their assigned duties. She (the principal) also reiterated her encouragement to teachers to make use of the computer laboratories, which in this instance can contribute to their professional development in acquiring both TK and TPK (See Table 1).

What was particularly striking about these short gatherings was the fact that the teachers at the two schools (A and C) that were observed spoke isiXhosa, the language spoken in many homes and schools in the Western Cape. Results from these study settings corroborate the idea of meaning negotiation put out by Wenger (1998). This notion includes language use, reaching an agreement, and carrying out work that requires constant attention and adjustments. Online meetings on platforms like WhatsApp also allow teachers to negotiate meaning, according to teacher K's interview answer at School C. Teacher K's comment aligns with the research of Magnusson and Godhe (2019) and Rani et al. (2023), who both contend that the use of communication technologies has made it easier to combine resources and create meanings using various media and modalities.

The teachers' motivation to learn CK, TK and TPK in their hybrid CoPs was fueled, in part, by their recurrent conversations that helped them create meaning. The findings from this study and from previous research highlight the potential for international collaboration among teachers, facilitated by hybrid CoPs that encourage cross-cultural exchange of pedagogical practices. We assert that communication is the fundamental basis for establishing connections and

structuring communities (Stănescu et al., 2022), whether for the deliberate or inadvertent aim of teachers' acquiring TPACK-related knowledge.

5.1.4. Teachers' identity (learning through becoming)

According to Wenger's (1998) assertion, identity can be understood as a process of knowledge acquisition through the act of becoming. Therefore, the term "identity" serves as a tool for conducting a sociological analysis of an individual's position within a group (Wenger, 1998). In this current study, teacher participants articulated both their identities and those of other teachers, as members of a hybrid CoP and as a collective, through one emergent sub-theme. Novice teachers, defined as newcomers who have just started their professional teaching careers, represent a sub-theme.

- *Peripheral participants (Newcomers)*

Phillips (2014) characterises an ideal CoP as a dynamic setting that allows newcomers access to knowledge and facilitates their active participation. This involvement enables these individuals to assimilate their newly acquired information into their identities as active community members. According to Lave and Wenger (1991), long-standing members of the community are considered core participants, while newcomers still acquiring knowledge about the CoP community are referred to as peripheral participants.

In the context of this research, Lave and Wenger's (1991) assumption about peripheral involvement does not correspond with the responses given by certain teachers in the survey questionnaires To the survey questionnaire, "*Apart from workshops organised and conducted by the WCG, how did you acquire your technological skills for teaching?*", Teacher F responded that they mainly learn these skills and acquire new knowledge (TK) from newly hired, or less experienced teachers, in terms of years of teaching experience.

Teacher F at School B:

> "*I get assistance from the colleagues around me, especially the newly appointed ones.*"

This, in turn, contributes to enhancing their (long-serving teachers) sense of belonging. These findings challenge Lave and Wenger's (1991) assertion that the concept of valid peripheral participation is easily applicable to both novice and inexperienced teachers joining an established CoP. Nevertheless, the findings of this current study appear to be in accordance with the results reported by Baya'a et al. (2019), who also discovered such results in their study. Conversely, , when answering the survey questionnaire's second question, "*Would you agree that at your school all educators are united and work as a team, and please elaborate?*", Teacher A from School A (as shown in Table 1) recognised the valuable support provided by experienced teachers regarding teaching strategies (PK):

Teacher A at School A:

> "*Yes, I agree, we do things together and all the time. We plan and share best practices. We do coach whereby the experienced teachers coach the*

novice teachers and vice versa, teachers who were not there when the experienced teachers were taught."

This finding highlights the relationship between newly appointed teachers and their more experienced colleagues, particularly in terms of knowledge sharing. It is evident that the CoP does not function solely as a space where experienced teachers act as mentors. Rather, the findings suggest that mentorship can be mutual: while novice teachers contribute by sharing TK, experienced teachers support them by sharing PK developed over years. This reciprocal exchange enriches the learning of all members within the CoP.

5.2. The constraints influencing primary school teachers' TPACK development in hybrid CoPs

Table 2 outlines the constraints hindering teachers' learning of TK, TPK, TCK, and TPACK within hybrid CoPs. It specifically highlights those teachers and their respective schools which indicated or implied the reluctance of some colleagues to engage with TPACK-related skills in these communities. Blank cells indicate no evidence of the constraint was found for that teacher/school/component.

Table 2: Constraints towards TPACK development in hybrid CoPs.

Schools	Teachers	Data collection tools	Community	Practice	Meaning	Identity
						Personal characteristics and traits
A	A	Questionnaires				
		Interviews				
	B	Questionnaires				
		Interviews				
	C	Questionnaires				
		Interviews				
	D	Questionnaires				
		Interviews				
		Observation WhatsApp texts				
B	E	Questionnaires				
		Interviews				TK, TPK, TCK, TPACK
	F	Questionnaires				
		Interviews				
	G	Questionnaires				
		Interviews				TK, TPK, TCK, TPACK
	H	Questionnaires				
		Interviews				
		Observation				

		WhatsApp texts				
	I	Questionnaires				
		Interviews				TK, TPK, TCK, TPACK
	J	Questionnaires				
		Interviews				
C	K	Questionnaires				
		Interviews				TK, TPK, TCK, TPACK
	L	Questionnaires				
		Interviews				
		Observations				
		WhatsApp texts				

5.2.1. Teachers' identity (learning through becoming)

Unexpectedly, identity-related resistance of some teachers to embracing new teaching methods and tools acted as a constraint to knowledge sharing within their hybrid CoPs. This reluctance, particularly evident among older teachers, represents a personal trait limiting their progress in becoming effective users of technology for teaching.

- *Teachers' personal characteristics and traits*

During the learning process individuals not only acquire new information but also cultivate and refine their identity characteristics (Wenger, 1998). Resistance to adopting innovative teaching methods, particularly among older teachers, illustrated by four teachers (E, G, I, and K) in Table 2, represents a characteristic that may hinder some teachers from achieving full proficiency in using technology for educational purposes. The following comments offer perspectives on the interview question, "*Why are certain teachers resistant to integrating technology in their teaching?*":

Teacher E at School B:

> "*I think young teachers believe in the use of technology, but the older teachers feels like it's a waste of time for them. Because I once asked one of our teachers 'why are you so against working with computers and stuff'? He said 'I'm too old to learn new things. It's only too late for me. It's good for you guys because you're still young'. So, I think it goes with the age in our school.*"

Teacher I at School C:

> "*Here at school, we've got a very big gap between teachers. We've got young teachers, and we've got older teachers. So, the older teachers feel challenged when it comes to technology. They don't feel comfortable regarding technology. The young ones have no problem in dealing with technology… The older teachers are reluctant to come down to the young teachers. And the young teachers don't want to go to the older teachers to teach them about technology.*"

Teacher E's response indicates that several teachers insist that their age impedes their capacity to acquire technological abilities, seeing this as unnecessary for them to engage in such learning. Thus, when they want to incorporate technology into their teaching, they have feelings of inadequacy and tend to avoid seeking assistance from the so-called "younger teachers," as noted in Teacher I's comment. These assertions correspond with the findings of Nikolopoulou et al. (2023) and Umugiraneza et al. (2018).

Table 2 shows the reluctance to embrace innovative teaching methods, particularly those which use technology, may be seen as a limitation hindering some teachers' readiness to develop TK, TPK, TCK, and TPACK within their hybrid CoPs. This suggests the presence of CoPs in schools does not always lead to teachers'collaborative learning, particularly when individual beliefs act as constraints. In the context of this study, the hybrid CoPs in Schools B and C did not appear to encourage older-generation teachers to acquire new skills from their peers.

However, as reflected in Table 1, other aspects of the hybrid CoPs did not seem to hinder the sharing or learning of TPACK-related knowledge. On the contrary, as Table 1 shows, the components in the CoP social learning theory often served as motivating factors, rather than constraints in supporting teacher learning.

6. Discussion

The study aimed to generate an understanding of the driving factors and constraints influencing primary school teachers' TPACK development in hybrid CoPs. To achieve this aim, the study employs Wenger's (1998) CoP social learning theory as a lens to explore the motivating factors and constraints teachers encounter in their hybrid CoPs in the course of their efforts to develop, or in some cases, their struggle to develop, TPACK. The TPACK framework (Mishra & Koehler, 2006) is used to identify the key areas of knowledge that the participants either gain or fail to acquire within these informal hybrid CoPs.

6.1. Driving Factors Facilitating TPACK Development in Hybrid CoP

The results indicated that, through social structures such as school-based ICT committees, teachers likely had a profound feeling of belonging within their hybrid CoPs, which served as a catalyst for the enhancement of their TK. These findings, along with other research (Hennessy et al., 2022; Razzak, 2015), indicate that teachers need support systems to enhance their ICT proficiency and confidence in using technology effectively in their teaching. The proactive involvement of school-based ICT committees in developing teachers' TK was apparent from Teachers C and G's interview responses (seen in Table 1) and from the examination of WhatsApp screenshots from School A and School C (refer to Figures 1 and 2).

The mechanism at play involved sustained peer interaction and social support that transformed informal collaboration into situated learning about digital tools. Teachers developed TK through shared problem-solving around issues such as attending to troubleshooting issues, and the setting up of equipment. The

screenshots indicate that committee members at those schools maintain their own WhatsApp group chats to deliberate on TK matters. The findings suggest the establishment of school-based ICT committees to support teachers' TPACK-related knowledge and skills could be adapted across various educational contexts worldwide, particularly in nations with limited financial resources for equipping teachers with TK, as this strategy may necessitate less financial investment than formal training.

Table 1 shows interview results revealed that practices involving teachers' problem-solving strategies were facilitating the teachers' acquisition of TK, PK, and CK, and that ongoing dialogues to negotiate meanings facilitated the acquisition of TK, CK, and TPK through their hybrid CoPs. Teachers A, C, and F described how they frequently discussed teaching challenges and shared solutions with colleagues, often focusing on integrating technology into their lessons. This type of collaboration functioned as a collective inquiry mechanism as teachers learned by doing. These discoveries underscore the need for open communication among colleagues as a method for enhancing collegial relationships within schools.

Stănescu et al. (2022) emphasise that communication serves as the fundamental basis for forming connections and organising communities. Recognisable patterns and standards of communication develop inside the group and are understood by all members. In addition, although the analysis of WhatsApp screenshots (Figures 1 and 2) does not explicitly reflect TPACK-related knowledge concerning practice and meaning, the presence of communication on this platform demonstrates its potential as a tool for problem-solving and provides evidence of ongoing dialogue among teachers within their hybrid CoPs.

These findings correspond with the assertions made by Magnusson and Godhe (2019) and Rani et al. (2023). In their studies, these writers saw communication technologies functioning as useful forums for professional exchanges among teachers, in this way facilitating collaborative problem-solving, resource sharing, and the exchange of teaching experiences and examples. Research (Magnusson & Godhe, 2019; Rani et al., 2023) and the present study show that social media functions as an expansive virtual environment akin to a staff room, facilitating teachers' engagement in teacher-led professional dialogues regarding pedagogical strategies and the resolution of practical teaching challenges.

Both the current study and previous research findings underscore the potential for international cooperation among teachers, facilitated by hybrid CoPs that explicitly promote cross-cultural sharing of pedagogical methods. The essential conclusion of our findings and literature is that worldwide hybrid CoPs are imperative, particularly in schools that possess some ICT tools but lack the means to maintain teachers' motivation to use these. Teachers D and K noted that the regular brief meetings on each or most days of the week allowed teachers to discuss curriculum (CK) issues and share content-related insights. The most compelling feature of the meeting observations and of the analysis of WhatsApp screenshots (Figures 1 and 2) is the teachers' evident proficiency in using IsiXhosa

as the principal language of communication. At School C, as it was observed, and as seen in Figure 2, the teacher's repeated dialogues indirectly led to the development of TK and TPK. The lack of this finding in previous literature complicates its explanation in the present study. However, the mechanism here involves iterative communication and contextual interpretation, consistent with Wenger's (1998) concept of meaning-making as an ongoing process of renegotiation. Teachers used both face-to-face and digital modes, such as WhatsApp to revisit previous topics, interpret new issues, and develop shared understandings of technology-supported teaching.

Also, we argue that a probable reason is the predominance of IsiXhosa as the principal language in a Khayelitsha township of the Western Cape province, and its position as the mother tongue for many inhabitants, which may make teachers more comfortable conversing in their mother tongue. This discovery corresponds with Wenger's (1998) description of "negotiation of meaning" within the framework of a CoP. This term comprises several parts, including language use, achieving agreement, and executing a job that requires concentrated attention and modifications (Wenger, 1998).

The present study's findings underscore the need to consider linguistic components in teachers' construction of their TPACK in schools through hybrid CoPs. This suggests creating CoPs that allow teachers use of their preferred language, should English not be their native tongue, fosters a more unified and effective hybrid CoP for tackling matters related to teachers' development and their application of TPACK. This aligns with the conclusion drawn by Tulloch et al. (2025) in their study: professional learning that is built around Indigenous language use strengthens both teachers' contextual knowledge and their agency.

This current study's findings contest the preeminence of English in TPD programmes, with significant implications for the design and execution of TPD projects globally. Our findings suggest integration of indigenous and local languages in TPD programmes may promote fairer and contextually relevant teacher learning experiences. A particularly notable and unexpected finding of this study emerged from the responses of Teachers A and F in the survey questionnaires. Teacher A recognised the valuable support provided by experienced teachers—based on their years of teaching—in sharing PK within their hybrid CoPs.

Conversely, Teacher K's survey response highlighted how novice teachers contributed TK to more experienced colleagues, demonstrating a bidirectional exchange of expertise shaped by differing levels of teaching experience. Teacher K's remarks indicate that newly appointed teachers who have only recently entered the profession possess greater technological skills and knowledge (TK), and potentially other forms of technology-related knowledge not listed in Table 1, such as TPK, TCK, and TPACK, compared to their more experienced peers. This finding is similar to that of LoBuono et al. (2020), who argue that reverse mentoring, where younger adults provide support and knowledge to older adults, can serve as a vehicle for teaching technology. This may be attributed to

the enhanced exposure and familiarity with modern educational technologies of newly trained teachers, acquired during teacher education programmes. This finding seems to align with the findings of Baya'a et al. (2019).

Novice teachers may possess less classroom experience, although having enhanced technological proficiency for teaching. In this context, newcomers may be seen as core members and key resources owing to their advanced knowledge and proficiency compared with veteran teachers. These findings challenge Lave and Wenger's (1991) limited concept of legitimate peripheral participation, one which implies that only long-serving members of a CoP can serve as mentors. The results of this current study suggest that core members are not always the ones who have been in the CoP the longest; in certain cases, newcomers or peripheral members may possess greater expertise and can assume mentoring roles soon after joining the CoP.

Our findings concerning (veteran) teachers' greater expertise in PK, compared with more technologically knowledgeable novice teachers' stronger understanding of TK have been discussed above, as have the benefits for veteran teachers' learning TK from novice teachers in terms of integrating TK in their teaching and enhancing confidence and professional identity. Therefore, we argue that a sense of belonging (identity) serves as a key motivator for the development of TK among teachers in schools.

6.2. Constraints Hindering TPACK Development in Hybrid CoPs

The findings discussed earlier suggest the hesitancy of older-generation teachers to adopt new technologies and to engage in peer learning can impede their ability to develop technological proficiency for teaching and learning and can impede them from becoming full members of their schools' hybrid CoPs. Some scholars (Nikolopoulou et al., 2023; Umugiraneza et al., 2018) view this resistance to change as a factor limiting certain teachers' competence in this domain.

In the present study this reluctance, particularly among older-generation teachers, was confirmed by four teachers. This phenomenon is corroborated by the findings of Nikolopoulou et al. (2023) and Umugiraneza et al. (2018). Teachers from previous generations may exhibit lower levels of comfort and familiarity with integrating technology into their classrooms, largely due to limited exposure during their professional careers. Their current resistance negatively affects both their own professional development and their learners' educational experiences.

Moreover, some teachers may see incorporating technology into teaching as unproductive, as an interruption of the important class time required for setup and debugging This may lead them to regard older techniques as more beneficial to reaching and learning. This perspective aligns with the findings of Guo and Wang (2024) and Mathipa and Mukhari (2014), regarding teachers' resistance to integrating technology in teaching seeing no advantages for themselves or their students. Building on the research of Nikolopoulou et al. (2023), Umugiraneza et al. (2018), and the present study, as illustrated in Table 2, it can be concluded that older teachers' reluctance to embrace change plays a significant role in their

willingness to acquire technology-related knowledge, such as TK, TPK, TCK, and TPACK, from their colleagues. This resistance may stem from a strong identification with traditional teaching methods, and a fear adopting modern approaches requiring abandoning familiar techniques. This finding indicates that establishing CoPs in schools does not necessarily result in collaborative learning among teachers, especially when personal beliefs serve as barriers.

In this study, as seen in Table 2, the hybrid CoPs in Schools B and C seemed to lack effectiveness in motivating older-generation teachers to learn from their colleagues, a challenge not limited to South Africa or developing nations; it affects developed countries such as Greece (Nikolopoulou et al.,2023), as well as emerging economies like China (Guo &Wang, 2024). Teachers' resistance to change can negatively affect their professional identities, with older-generation teachers struggling to fully assume membership of a hybrid CoP within their schools. Addressing this challenge requires the implementation of targeted, well-structured, and context-specific interventions.

7. Conclusion

This study aimed to explore the driving factors and constraints influencing primary school teachers' TPACK development in hybrid CoPs. The findings suggest that Wenger's (1998) four CoP dimensions, community, practice, meaning, and identity, largely functioned as motivating factors that influenced the teachers' TK, PK, CK, and TPK; conversely, the community dimension also functioned as a constraint factor for teachers' limited learning of TK, TPK, TCK, and TPACK. These findings emphasise the significance and value of CoPs, especially those that integrate in-person and online platforms, enabling educators to acquire essential technological expertise for their teaching efforts.

To enhance the potential for teachers' TPACK development, planned interventions are essential, in the form of encouraging flexible informal and formal mentorship that adapts the hybrid CoP approach to existing and potential constraints and contexts. Thus, the particular resistance to change phenomenon may be acknowledged by national governments and international development organizations, such as the COL, and the UNICEF, whose aim is to support scalable, contextually responsive models of teacher capacity building in resource-constrained settings which limit the advancement of teachers' TK, TPK, TCK, and TPACK in schools.

Ultimately, this study advances ongoing scholarly and policy-oriented conversations on educational change. Thus, the findings also offer insights for policymakers and educators seeking to design context-responsive professional development. However, it must be noted that the study's limited sample and qualitative scope restrict generalizability. While this small-scale case offers valuable findings, future longitudinal research is needed to examine the educational change, sustainability, and scalability of hybrid CoPs in advancing teachers' TPACK development over time.

Conflict of interest
On behalf of all authors, the corresponding author states that there is no conflict of interest.

Declarations
Ethics statement: This study involved human participants who acted as respondents. The authors ensured that no personal identifiable or sensitive information, such as names, physical addresses, or photographs, was disclosed, thereby upholding the participants' right to data privacy. Ethical clearance for the study was granted by the Ethics Review Board of the Cape Peninsula University of Technology on 27 October 2022, and by the Western Cape Department of Education on 31 March 2023.

Informed consent:
Written informed consent, including consent to participate and consent to publish, was obtained from all participants before their involvement in the study.

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Data availability
The data supporting the findings of this study are accessible; however, due to certain restrictions, they are not publicly available. Interested parties may obtain the data directly from the authors upon reasonable request.

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