Affective and Professional Knowledge Components: An Assessment of their Association and Implication in Primary School Mathematics Teacher Education

Kassa Michael*[1] and Mulugeta Atnafu[1]

[1] *Department of Science and Mathematics Education, College of Education and Behavioural Studies Addis Ababa University, Ethiopia*

Corresponding*: kassa.michael@aau.edu.et

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Abstract

The competence of pre-service teachers at teacher education colleges is at stake in Ethiopia where some are attributed to knowledge dimensions and the other to affective dimensions. This Study assessed the association between the knowledge dimensions and affective components pre-service teachers should possess by employing a correlational survey design and indicating implications. A sample was drawn from nine colleges of teacher education (CTE) which was selected using stratified sampling. Those selected regions that have only one CTE were selected based on availability sampling. The Study employed questionnaires with five-point Likert scale-type questions. Factor analysis followed by correlational analysis was conducted to reduce data. As a result, the seven knowledge components of technological pedagogical content knowledge were significantly correlated among each other. The three affective component variables were also significantly correlated. The aggregate of knowledge and affective variables were found to have a significant correlation with around 42% of common variance. Despite these, the primary and secondary factor loadings were extracted. The Study result indicates a strong association between knowledge and affective components. Thus, it has been recommended that the capacity of teacher educators should be enhanced and a teacher education program that fulfills both ends to meet the demands for teacher knowledge for teaching and concerned bodies should be developed. Also, attention should be given to enhancing affective constructs through integrating content, pedagogy, and technology beyond the usual knowledge related concerns.

Keywords: *knowledge components, affective components, association, Implications, primary teacher education*

Introduction

Teachers are at the center of teaching-learning. They are key factors for quality learning to happen. To this effect, teacher education plays an important role in training competent teachers. Nonetheless, the emphases attributed to the organization and implementation of teacher education are debated among scholars of education (Hammond, 2024) leading to varying types and nature of teacher education programs. These aroused mutual uprising concerns of both governments and the larger public demonstrated by dissatisfaction with the ongoing teacher education, especially in the low-income countries (UNESCO, 2022). Methodological considerations in teacher education and issues of professional competence are among the issues of concern among professionals (Kassa, 2015). In addition, key requirements for enrolment in teacher education include academic standing and interest among other things (MoE, 2023) with the view – having both leads to success. Thus, trying to address issues related to teacher preparation is crucial in an educational system, where one of the issues is an association between the knowledge of teachers and their affective constructs. Scholars have forwarded varying ideas on the ongoing teacher education in Ethiopia. Tesfaye (2014) says 'reforming the existing lower and upper primary teacher preparation programs should be an urgent priority' and Amka (2020) noted that teachers' positive attitudes play an important role in driving the success of education change in schools. Buabeng and Akuamoah-Boateng (2019) further justify that there is a clear understanding of the impact of teachers on academic success on the part of both teachers and students, and the potential of meeting both needs – knowledge, and interest should be the focus of teacher education.

Blömeke and Delaney (2012) also found out that an examination of [mathematics] teachers' knowledge is an important parameter of school quality, and they further reiterated that it is important to ascertain whether and how teacher training contributes to the development of teacher knowledge. Similarly, the Ministry of Education (MoE) of Ethiopia aspires candidates to teacher education must prove to have an interest in the profession and there is a need to further strengthen teacher training and qualifications at primary and secondary levels (MoE, 2010). The MoE in its recent Education Roadmap further specifies that one of the purposes of shifts is 'to ensure the provision of adequate qualified and motivated teachers to provide relevant teaching, training, and learning opportunities for all children, youth and adults in all sub-sectors of education and training throughout the country' (MoE, 2018, p.53). These points indicate the need for trained and competent teaching staff, where teachers must have sound knowledge including content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK), and affective domains in becoming a teacher. Concerning these the MoE asserts that:

Schools in Ethiopia are struggling to offer high-quality instruction and continue to fail in their quest to improve the teaching and learning of science and mathematics. And despite the efforts made, both by the ministry and the schools, the improvements seem limited (MoE 2010a. p.3).

More and better teachers are needed if proficiency is indeed to become a widely held competence that encompasses both knowledge and affection (Adler et al., 2005) as quality instruction depends largely on teachers. Since recently, teacher educators' instructional practices are among the factors that impact affects (Anteneh et al., 2021). So, the preparation of teachers endowed with both knowledge and affection is crucial. Inconsistent mathematics teacher education programs at both the colleges of teacher education and universities, and ongoing dissatisfaction with the overall quality of teacher education instigates the need for studying the ongoing teacher education, and the link between knowledge and affective dimensions of preservice teachers. This Study thus sought to investigate mathematics teacher education and explicate the observed association between trainees' knowledge and knowledge components and their affective constructs to becoming a teacher.

Statement of the problem

It is well noted that teacher education has to be relevant to the principles it is established for and should meet teachers' needs of building sound knowledge and positive affect towards becoming a teacher. However, in Ethiopia, the pool of prospective teachers admitted to a teacher training college is made up of a low-achieving group (Tesfaye, 2014). The MoE also declared that the teaching profession is still not attracting high-caliber entrants who wish to remain in teaching (MoE, 2008, 2018). As stipulated by Senk et al. (2008), government officials and policymakers in many countries share a common concern that too many teachers are ill-equipped to teach mathematics well. The Fifth Education Sector Development Program (ESDP V) targeted that at the end of the period (2019/20), 100% of the teachers for the primary first cycle (Grades 1-4) and primary second cycle (Grades 5-8) should have the minimum required qualification for both sexes, but the target has been unraveled (MoE, 2020). Solomon (2022) in turn reported that the attrition of well-trained teachers is a severe problem in peripheral and rural schools in Ethiopia. The MoE (2020) also noted that the attrition of teachers is excessive manifesting the prevalence of challenges related to the affection of the teachers that could not allow them to stay in the profession.

The MoE (2010) has noted that sometimes teachers exhibit negative attitudes towards science and mathematics. It was also noted that the number of properly qualified teachers in Ethiopian schools is less than 50 percent and those that are qualified are not well versed in the professional pedagogical skills that teachers are required to possess (MoE 2010a). Such problems have forced the Ministry of Education of Ethiopia to make repeated revisions and reforms to teacher education. However, no sufficient study has been conducted to explore the association between teachers' knowledge and their affective dimensions to identify possible solutions to the recurring problems and foresee its implications. A reform on general education curriculum that transcends to teacher education is also underway. Currently, the MoE is developing a teacher education curriculum framework that needs inputs founded by research studies, where future teachers could have both knowledge and affect to help them build the professional competence as teachers during their stay at the teacher education. Hence, studying this kind of problem will account for both theoretical and practical significance and can serve as an input to the ongoing reform initiatives by identifying the extent of association between the two, and associated implications. This Study, thus, has tried to answer the following research questions.

1. What is the association between each of the components of knowledge of the preservice teachers?
2. What is the association between each of the affective domains of the preservice teachers?
3. What is the association between the synthetic knowledge and affection of preservice teachers?
4. What implications do the association between knowledge and affection have for improving the quality of teacher education?

Literature Review

Teachers' Knowledge and Affective Components and Impact on Students' Learning

a) *Teachers' Knowledge and its Impact on Students' Learning*

Teacher quality matters a great deal for student learning and achievement, and there is extensive literature on the topic (Holvio, 2022). Teachers' knowledge of both content and pedagogy is important in teaching-learning. Teacher knowledge focuses on enabling teachers to fulfill their central role: teaching subject matter using appropriate pedagogical principles and skills (Ben-Peretz, 2011). Shulman (1986) initiated what teachers need to know about students' learning by coining the term pedagogical content knowledge. Such knowledge significantly contributed to various aspects of teaching (Even & Tirosh, 2008) including content knowledge and pedagogical knowledge among other things. In addition, experimental and other tightly controlled professional development studies on how students learn subject matter (Franke & Kazemi 2001) have helped identify classroom practices, and an emphasis on identifying and remediating holes in the teachers' knowledge may be more helpful for the teachers' effectiveness (Sadler et al., 2013). Nevertheless, teacher knowledge for teaching is emerging as a research area in the field. Hill and Chin (2018) stated the presence of incomplete evidence regarding how well teachers' capacities in the domain of teacher knowledge can be measured and how such teacher capacities relate to other forms of teacher knowledge, such as subject matter knowledge.

b) *Teachers' Affective Components and their Impact on Students' Learning*

Attitudes and beliefs are important concepts in understanding teachers' thought processes, classroom practices, changes, and learning to teach (Richardson, 1996). Teachers' beliefs about pedagogy are closely related to their beliefs about how their students learn and instructional practices depend on what teachers bring to the classroom (OECD, 2009). Self-efficacy predicts teachers' efforts, and the efforts increase teachers' chance of experiencing mastery (Agyekum, 2019) and their relations with the students where the research field of teacher-student relationship quality has evolved over the past three decades (Fabris, et al., 2022) dignifying the importance of studying teacher's affective constructs. These also explain that the approach teachers choose to teach a certain concept and other forms of knowledge are subject to their beliefs. In addition, the attitude of teachers is correlated positively and significantly with students' academic performance (Ekperi et al, 2019). These pieces could account for the overall teachers' affection, but issues related to their motivation, perception, and practical engagement are considered in this particular article. The points noted above highlight how much knowledge and positive affection impact developing professional competence and learning. If these two are treated in aggregate, it is expected that they can improve practice and achievement through developing preservice teacher competence.

Knowledge Components Attributing to Teachers' Professional Competence

Teachers' knowledge is important for learning to take place. Teacher knowledge is diverse, but their knowledge in terms of subject matter, pedagogy, and technology is promoted especially after the emergence of TPCK of Mishra and Koehler (2006). The Framework describes the relationship between the knowledge domains adopted by Koehler and Mishra (2008) and each of the knowledge components useful for teachers is described below. The knowledge components are also measured through self-response questionnaire, and with a scale (Landry, 2010)

a) ***Subject Content Knowledge (CK)***

Content knowledge is essential for prospective teachers to possess and can be considered as knowledge about the subject such as mathematics and its structure (Turnuklu & Yesildere 2007). Fennema and Franke (1992), for example, argue that if a teacher has a conceptual understanding of mathematics, this positively influences classroom instruction. Hill et al, (2008) also declared that programs and professional development opportunities often focus on developing teachers' knowledge. Hannula (2017) on his part stated that subject matter knowledge plays a significant role in a teacher's professional competence. According to UNESCO-IIEP (2022), several studies have found that teachers' content knowledge has significant positive effects on student achievement. Yet, teachers in many countries around the world still lack part of the content knowledge necessary for their teaching. These imply that a competent teacher needs to have solid content knowledge because anyone who has a gap in content knowledge cannot in any way convey the content sufficiently.

b) ***Pedagogical Knowledge (PK)***

The knowledge one has about teaching and the essential skill for teaching is pedagogical knowledge. Lack of pedagogical knowledge influences teachers to focus on either mere factual teaching or fail to capture the horizon of learning as teachers need to know not only what to teach, but also how to teach and improve student behavior. Strengthening this, Fennema and Franke (1992) and Turunklu and Yesildere (2007) noted that if teachers do not know how to translate abstractions into a form that enables learners to relate the mathematics to what extent they already know, they will not learn with understanding. Teachers' pedagogical knowledge base is not static as new knowledge emerges from research or is shared through professional communities, and this knowledge needs to be accessed, processed evaluated, and transformed into knowledge for practice (Guerriero, 2017).

c) ***Technological Knowledge (TK)***

These days, technology is not only a privilege but a necessity for the teaching-learning of Mathematics. Technology which is essential in teaching and learning mathematics influences the mathematics that is taught and enhances future teachers' learning (NCTM 2000, p. 24). The technological knowledge consists of both hardware and software useful for teaching. In addition, mathematics teaching is a deeply mathematical act that is built on a base of mathematical understanding and that also calls for different types of knowledge (Schoenfeld, 2005), one of the required types of knowledge being technological. Technological knowledge of teachers is essential and needs to be improved in selecting variations in the use of software, the creativity of teachers in packaging technology-based materials, and teacher innovations in integrating technology into learning (Wuryaningtyas & Setyaningsih, 2020). Thus, future teachers need to know emerging technologies that are useful for instructional purposes. Such knowledge of technology helps them choose the proper technology for specified instruction and the specific application of these for specific mathematical content.

d) *Pedagogical Content Knowledge (PCK)*

Teacher education institutions are mandated to educate and make teachers qualified in both content knowledge and pedagogical knowledge. Scholars like Shulman (1986) have suggested pedagogical content knowledge (PCK) and described it as the particular form of content knowledge that embodies the aspect of content most germane to its teachability. Temechegn (2011) also stated that "a teacher must first comprehend the material to be taught, that is, grasp the relevant content knowledge (CK). This must, however, be transformed by the use of pedagogical-content knowledge, into a form in which it can be taught" (p.1). In light of that, College of Education of Addis Ababa University (CoE) also presented that:

> *the process of teaching must be dynamic and reciprocal, responding to the many contexts within which future teachers learn. Such teaching demands that teachers integrate their knowledge of subjects, pedagogy, psychology, future teachers, the community, and curriculum to create a bridge between learning goals and learners' lives, not simply filling the mind with rigid content that is learned through rote memory* (CoE, 2008, p. 20).

The focus in this knowledge domain is the ability of teachers of mathematics to use a variety of teaching approaches proper for specific mathematics content teachers have.

e) *Technological Content Knowledge (TCK)*

When examining the use of technology in education, the idea of how teachers learn is important for teacher education programs to consider (Herron, 2010), and is a place preservice teachers encounter with applications of emerging technologies for education. TCK is useful for selecting the proper technology for teaching certain content. For example, the technology for teaching geometry and algebra might not be always the same. Hence, it will be useful to know such technologies that are useful for teaching mathematics since "Teacher education programs need to examine methods that allow for elementary pre-service teachers to gain the knowledge necessary for implementing technology into the mathematics classroom" (Herron 2010, p.27). This is so because teachers these days must be aware of the demands of teaching in and for the 21st century (Zorlu & Zorlu, 2021) and practical experiences during their stay in teacher education give impression and insight into the nature of the teaching profession.

f) *Technological Pedagogical Knowledge (TPK)*

TPK is knowledge of the "existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies" (Mishra & Koehler 2006, p.12). Several researchers have acknowledged misconceptions about the meaning of "technology integration" among educational practitioners and administrative staff after the technology was introduced on their campuses (Hsueh, 2008). He further stated that technology integration is not putting computers in the classroom without teacher training. Harris, et al., (2007) also criticized current technology training methods as unduly techno-centric and as not considering the dynamic and complete relationship connecting technology and pedagogy.

Teacher education programs must prepare future teachers to effectively use technology in mathematics instruction (Herron 2010). But Carlson and Gooden (1999) reported that many pre-service teachers feel that they are not prepared to teach using technology after they graduate. The use of technology for pedagogical purposes is continually advancing making it relevant to consider in teacher education programs. However, the challenges that relate to identifying and implementing methods to most effectively integrate technology in the educational context (Johnson, et al., 2016) are evident. The emergence of COVID-19, however, brought about extensive studies and practices of integrating technology for pedagogical purposes where knowledge of the capability of various technologies including affordances and constraints influence pedagogical designs and strategies in a teaching and learning setting (Kim, 2018).

g) *Technological Pedagogical Content Knowledge (TPCK)*

TPCK represents the thoughtful interweaving of all three key sources of knowledge – technology, pedagogy, and content (Mishra & Koehler 2006). Hence, TPCK describes how teachers' knowledge of technology, content, and pedagogy interact to use technology strategically for instruction (Landry, 2010, p.71). The intent of TPCK is to provide a framework to discuss the facets of teacher knowledge, not to propose a course for teacher instruction (Harris et al, 2009). However, it is noted that TPCK also enables teachers to successfully incorporate technology in teaching by enabling the teachers to make appropriate, context-specific strategies (Zaidi & Hussain, 2020). For this study, teacher education institutions need to set a mechanism on how to integrate these three sources of knowledge. Landry (2010) argues that "Mathematics teacher educators must provide teachers the TPCK experiences necessary to use technology strategically in their mathematics instruction" (p.72). This is so because, like technology, future teachers, and classroom contexts change. And TPCK provides a dynamic framework for viewing teachers' knowledge necessary for the design of curriculum and instruction focused on the preparation of their future teachers for thinking and learning mathematics with digital technologies (Niess et al., 2009). Digital technologies assist in developing abilities that will require students' professional performance, such as problem-solving, thinking structure creation, and process comprehension (Haleem et al., 2022).

Affective Constructs Attributing to Teachers' Professional Competence

Effective teachers do not only seek the sources of knowledge discussed above but also affection to becoming a teacher as beliefs or attitudes are a crucial part of mathematics teachers' competence (Richardson 1996). Several studies have indicated that the concept of professional competence is a multidimensional concept that seeks to integrate several affective constructs to influence student learning (Blömeke, 2017; Hill & Chin, 2018; Jentsch & König; Kaiser, 2019). There is ample evidence that aspects beyond knowledge may be important in determining teacher success (Kunter et al., 2013). According to the study by Kunter and colleagues, these aspects include teachers' beliefs, work-related motivation, and the ability for professional self-regulation. Because of this, teacher beliefs and meta-cognitive dispositions have to be included to develop a full model of teacher competence (Blömeke, et al. 2014). Attitude, interest, readiness, engagement, perception, belief, value, motivation, etc., are all among the variables substantiating the affective elements. However, several researchers use varying approaches to measuring affection and factors that need consideration in becoming effective and competent teachers (Schoenfeld, 2010) such as value chains, respect, societal norms, etc.

In addition, the personality traits of the teachers are more powerful and influential than the course content or instructional strategies used in the classroom, indicating the importance of studying affective constructs. Given this necessity of studying affective elements for teachers, the variables that need to be considered are so vast and need to be comprehended. Attitude, interest, readiness, engagement, perception belief, value, etc., are all variables substantiating the affective elements. But, concerning related theoretical and practical aspects of teacher education, the affective elements considered for this study were attitude/motivation, engagement, and perception, where attitude/motivation stands for the overall belief the preservice teachers have, engagement depicting hard work and readiness for continued development, and perception the view preservice teachers have before they start teaching at the school. Of these, only three variables (motivation, engagement and perception) were selected after running principal component analysis for a list of several items extracted from various literature sources where autonomy failed to be reliable and hence ignored. It is worth noting that a brief description of these variables is given below. It was also identified that motivated preservice teachers are engaged learners, and this impacts their perception of becoming a teacher. Hence, it is important to treat affect constructs and their association with the teacher knowledge categories mentioned above.

a) *Motivation*

Motivation as a personal trait of becoming a teacher is a useful construct that has to be established. The Guideline of the Ministry of Education expects entrant preservice teachers to be motivated to become teachers and should demonstrate interest. Teachers need to be motivated and willing to apply their knowledge (Blomeke & Kaiser, 2017). Motivation is a key driver that influences preservice teachers to behave, and this impulse moves them to do something following the drive in them. It is revealed that teacher motivation has a significant impact on teacher performance (Sandriyani et al., 2021) and thus ensuring preservice teachers have the motivation is essential as one construct to develop professional competence.

b) *Engagement*

Engagement as an affective construct reflects the voluntary allocation of preservice teachers' resources and energy across their activities (Klassen et al., 2012). It is thus demanding due attention to embedding it in teacher education programs to unveil the extensive attrition from the profession at later times. Teacher professional learning is expected to provide opportunities to promote engagement. Thus, accumulating evidence on preservice teacher engagement is a crucial dimension of their professional development. This is so as lack of engagement cripples learning, whether we're talking about students or teachers (Wolpert-Gawron, 2020).

c) ***Perception***

The perception of individuals on becoming a teacher before they enroll in teacher education programs may persist or erode during their stay in the program. Teacher education programs are expected to boost positive perceptions and love of the profession. In the Ethiopian context, teaching has not only eroded its nobility but has also been engulfed by incompetent professionals (Mekonen, 2018; Mihiretie, 2023; Tessema, 2015). These contextual situations have a cascading influence on the perceptions preservice teachers have for the teaching professions, and that in turn affects their professional competence. In addition, the perception of teaching as a profession has a significant influence on their motivation to do well in their teacher training program, and it boosts teachers' cognitive ability and affective disposition which empowers improvement through innovative teaching and learning by teacher trainers and the teacher trainees (Nenty, 2015).

Professional competence as nexus of Knowledge and Affective Domains

Based on the narratives provided above, the study aspired the model given as follows.

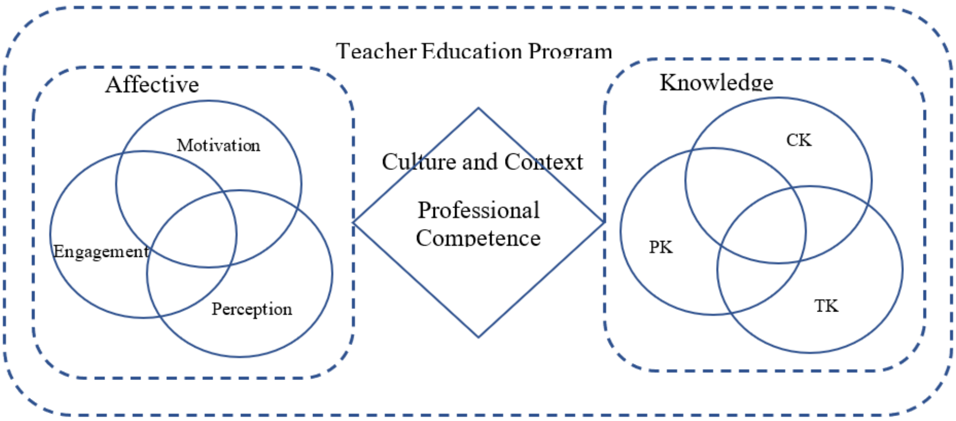

Figure 1: *A model for the association between knowledge and affective components*

Materials and methods

Research Design

A survey is used to collect information about people to describe, compare, or explain their knowledge, feelings, values, and behavior (Fink 2013). This Study was designed to investigate the association between knowledge and affective constructs of preservice teachers as it was manifested during the time of data collection. This Study was conducted based on cross-sectional survey design where data were collected at one point in time about the knowledge and its dimensions, and affective constructs that prevailed important for the study.

Population and Sampling

The population for this Study constituted all prospective teachers studying to be mathematics teachers at the colleges of teacher education in Ethiopia. The preservice teachers in the final year for graduation were selected because these can show the teachers' education process and their readiness as individuals to be teachers at their respective educational levels.

Since there were many colleges of teacher education for primary schools during the time of the study, it was not feasible to encompass all these colleges. Hence, the Study used a sample. For this purpose, the Study used probability sampling method. However, selecting the CTEs randomly alone was not sufficient, as some CTEs did not have graduating students. For this reason, some informed judgment was employed to filter out some of the CTEs using some exclusion criteria. The case in point was, excluding those CTES that had no graduates. Then stratified sampling with a cluster of CTEs as strata was employed to select specific CTEs from which the preservice teachers in their final year were involved in the study. Applying Cohen, Manion, and Morrison (2007) ten CTEs and all the prospective teachers in their final year for graduation at each of the selected ten CTEs were included in the Study.

Variables

In this Study, the two major variables, knowledge and affective constructs, were considered as dependent variables. These were also classified into seven domains of knowledge (content, pedagogy, technology, and their joint considerations) and three domains of affection (motivation, engagement, and perception) as sub-variables used as predictor variables of the dependent variables.

Data Collection Instruments

Landry (2010) assured that questionnaires can serve as an assessment tool to reliably assess components of the mathematics-TPCK framework. The affective constructs were also examined through self-responded questionnaires. Based on these, the Study employed two types of self-responded questionnaires for the seven knowledge domains and the three affective domains with five-point Likert scale-type questions. The instruments for knowledge domains were adapted from the cross-country studies such as MT21 and MKT studies (Blomeke et al. 2012; Tatto et al. 2012; Delaney et al. 2008; Hill et al. 2008), TEDS-M (Tatto et al., 2008; Schmidt et al., 2009) and modified to fit to the Ethiopian context. Likewise, instruments of scale were also used to measure the affective domains (motivation, engagement, and perception) that were adapted, modified, piloted, and validated for the purpose.

The first questionnaire of knowledge domains consists of a total of 46 items with seven major scales of CK (8 items), PK (9 items), TK (6 items), PCK (7 items), TCK (5 items), TPK (4 items), and TPCK (7 items). The second questionnaire deals with the affective domains with a total of 26 items presented in four major scales – motivation (10 items), engagement (8 items) and perception (8 items).

Validity and Reliability of the Instruments

Factor Analysis and Correlational Analysis were used to ensure construct validity. Additional validation by seven content and pedagogical experts was also employed for face and content validity. The instruments were initially pilot tested at the Kotebe University of Education with 78 prospective teachers. Internal consistency reliability of the scales both at the piloting and after final data collection were ensured by Cronbach’s alpha. The Cronbach’s Alpha at the end of the study for the knowledge domains were: CK (0.85), PK (0.89), TK (0.83), PCK (0.86), TCK (0.84), TPK (0.76), and TPCK (0.84), and for affective domains were: Motivation (0.73), Engagement (0.73), and Perception (0.71). The overall reliability of knowledge domains was 0.83 and that of affective domains was 0.74 which shows that both are within the acceptable minimum range of 0.7.

Data Collection Procedures

After piloting, the English version of the instrument was translated into the medium of instructions that are used by each of the sampled institutions, i.e. Afan Oromo, Amharic, Tigrigna, and Hëmtana. This helped the would-be teachers to be able to fill the questionnaire in a language they use as a medium of instruction and help them respond meaningfully controlling the response errors that could emanate from language barriers. During the translation, both the original version and the forward-backward translated version in English were tested by prospective teachers who were not considered in the Study for the strength of association, and correlation was checked that verified a strong positive hold of working with the translated versions of the instruments. After finalizing those tasks data were collected during the regular academic calendar by deploying trained data collectors.

Methods of Data Analysis

The data collected for this Study were analyzed following each leading question. In addition, statistical techniques such as factor analysis were employed to identify factors that conduit knowledge and affective constructs of would-be teachers. The factor analysis classified TPCK and the three affective domain components into two addable clusters. Correlational analysis was also conducted for the association between the knowledge domains and affective domains and their components.

Results

Association between the Knowledge and Affective Components

An attempt was made to see the association between the set of variables on teachers' knowledge and that set of variables of preservice teachers' affective constructs. Table 1 shows that each pair of the seven knowledge domains was significantly correlated with a large effect size between PK and PCK, r(468)=.80, p<.001.

Table 1: Pairwise Inter-correlations, Means, and Standard Deviations for knowledge domain variables

	CK	PK	TK	PCK	TCK	TPK	TPCK1	TPCK2	Mean	SD
1. CK	--	$.66^{**}$	$.47^{**}$	$.61^{**}$	$.45^{**}$	$.45^{**}$	$.50^{**}$	$.42^{**}$	3.95	.64
2. PK		--	$.48^{**}$	$.80^{**}$	$.49^{**}$	$.57^{**}$	$.50^{**}$	$.54^{**}$	4.22	.59
3. TK			--	$.52^{**}$	$.63^{**}$	$.60^{**}$	$.52^{**}$	$.49^{**}$	3.52	.80
4. PCK				--	$.58^{**}$	$.60^{**}$	$.54^{**}$	$.56^{**}$	4.23	.61
5. TCK					--	$.70^{**}$	$.60^{**}$	$.51^{**}$	3.82	.75
6. TPK						--	$.50^{**}$	$.63^{**}$	3.94	.72
7. TPCK 1 (Ability to operate technology)							--	$.51^{**}$	3.06	.77
8. TPCK 2 (Actual usage of technology)								--	3.04	.84

**. $p < 0.001$

The Table shows that PK is positively and strongly associated with PCK. TPK was also positively correlated with TCK r(475)=.69, p<.001 which also has a large effect size according to Cohen (1988). In addition, CK and PK were strongly correlated r(564)=.66, p<.001.

Table 2 presents the association between the components of affective variables.

Table 2. Pairwise Intercorrelations for Affective Domain Variables

Affective variables	1	2	3	4	5	6	Mean	SD
1. Motivfactor1[2]	--	-.13**	.69**	-.23**	.47**	-.16**	4.35	.70
2. Motivfactor2[3]		--	-.08	.45**	-.03	.31**	2.45	.83
3. Engafactor1			--	-.19**	.61**	-.20**	4.19	.75
4. Engafactor2				--	-.15**	.36**	2.31	.83
5. Percfactor1					--	-.15**	3.92	.82
6. Percfactor2						--	2.27	.90

**. P < .001;

Table 2 shows that each pair of the three affective domain variables are significantly correlated. The strongest positive correlation with a large effect size was between positive motivation and positive engagement, r(439)=.69, p<.001. Positive engagement was also positively and significantly correlated with positive perception towards becoming a mathematics teacher r(445)=.61, p<.001 with a large effect size (Cohen 1988).

Cognizant of the associations between each subcomponent of the knowledge domains and the affective domains, it beseeched an interest in checking the association between the subcomponents of each domain.

Table 3. Pearson correlation between the knowledge domains vis-à-vis affective domains

Affective Domains	Motivation		Engagement		Perception	
	factor1	factor2	factor1	factor2	factor1	factor2
Knowledge Domains						
CK	.43**	-.02	.45**	-.12**	.36**	-.14**
PK	.44**	-.08*	.51**	-.15**	.35**	-.18**
TK	.28**	.09	.34**	-.02	.33**	-.07*
PCK	.49**	-.11**	.54**	-.21**	.39**	-.23**
TCK	.30**	-.00	.35**	-.10*	.36**	-.09**
TPK	.37**	-.02	.39**	-.15**	.34**	-.11*
TPCKFactor1	.37**	.02	.39**	-.15**	.34**	-.11**
TPCKFactor2	.41**	-.07	.46**	-.08*	.38**	-.15*

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

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

[1] Stands for positive affection; 2 Stands for negative affection; The same coding is valid for the others as well.

Table 3 indicates that all the knowledge domain subcomponents are significantly correlated with engagement and perception; and with the first factor of motivation (positive motivation). The only items that significantly correlate with the second factor of motivation (demotivation) were the PK and the PCK. The strongest positive correlation was between PCK and the first factor of engagement (engaging), r(442)=.54, p<.001 with a large effect size according to Cohen (1988) and showing that those who have relatively better PCK were likely to have better engagement. Therefore, PCK needs attention. PK is also positively correlated with engagement r(437)=.51, p<.001 with medium to large effect size according to Cohen (1988). Those that are significantly correlated with positive motivation were PCK, PK, and CK in order of their strength. From these, one can see that it is useful to focus on PCK, PK, and CK seeking the useful integration of content and pedagogy.

Canonical correlation analysis was performed for linear combinations of each group of variables. In this case, the possible number of pairs was limited to the number of variables in the smallest group, which in this case was six (the number of subscales of the affective domains). The following presents the canonical correlation and associated characteristics.

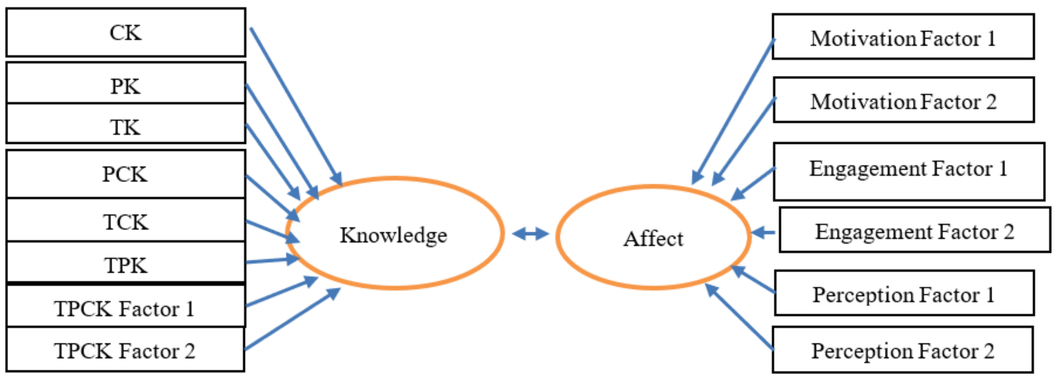

Figure 2: *Association between knowledge and affective constructs*

The Canonical correlation considered the eight knowledge domain variables as predictors of the six affective domain variables to evaluate the multivariate shared relationship between the two variable sets (Knowledge and affect). The analysis yielded six functions with squared canonical correlations (R2c) of .372, .044, .017, .008, .004, and .003. The first canonical correlation was found to be .61 (37.23% overlapping variance) and the second was .21 (4.37% overlapping variance). Peel-off test was also conducted from which all canonical correlations included Wilks' Lambda and corresponding tests revealed that the correlations are statistically significant, Λ =.582, F(48, 2552.84) = 6.195, p = .000 meaning that the two variables sets (knowledge and affection) have a relationship. The r2 type effect size was 1-.582=.418 which indicates that the full model explained a substantial portion, about 42% of the variance shared between the two variable sets, which is a large effect size.

Table 4: *Correlation and Standardized Canonical Coefficients between the knowledge domain and the affective domain variables*

Item Contents	First Canonical Correlation		Second Canonical Correlation	
	Loading	Coefficient	Loading	Coefficient
Knowledge Domains				
Content Knowledge	-.76	-.30	-.29	-.20
Pedagogical Knowledge	-.80	.00	-.08	-.27
Technological Knowledge	-.51	.12	-.62	-.75
Pedagogical Content Knowledge	-.93	-.60	.22	1.05
Technological Content Knowledge	-.65	-.03	-.33	-.14
Technological Pedagogical Knowledge	-.67	-.12	-.09	.29
TPCK Factor 1(ability to operate technology)	-.74	-.23	-.41	-.51
TPCK Factor 2 (practical usage)	-.56	-.01	-.06	.10
Affective Domains				
Motivation Factor 1 (Motivated)	-.82	-.33	.18	.26
Motivation Factor 2 (De-motivated)	.15	-.00	-.75	-.58
Engagement Factor 1(Engagement)	-.92	-.46	-.07	-.04
Engagement Factor 2 (Disengagement)	.39	.12	-.67	-.56
Perception Factor 1 (Positive Perception)	-.81	-.33	-.32	-.45
Perception Factor 2 (Negative Perception)	.33	-.00	.01	.39
Same Set % Variance	50.79		10.20	
Redundancy	18.91		.45	
Canonical Correlation	.61		.21	
r^2_c	37.23%		4.37%	
(sig)	($p < .001$)			

Table 4 presents the standardized canonical function coefficients (loadings) and the structure coefficients (coefficients) for functions 1 and 2. Looking at the function 1 coefficients, one sees that the variables PCK, PK, CK, and TPCK Factor 1 were relevant primary predictors with TPK, TCK, TPCK Factor 2, and TK making secondary contributions to the synthetic variable (knowledge). All the variables' structure coefficients except PK and TK have the same sign, indicating that they were all positively related.

Discussion

Following the seminal work of Shulman (1986) that brought the idea of PCK, varying perspectives and interpretations of PCK have been taking place. Researchers such as Mishra and Koehler (2006) came up with the notion of TPCK (and later TPACK) incorporating technology. Though TPCK as a framework is believed to enhance quality, developing the notion of TPCK alone is insufficient unless the affective variables are also equally considered. According to Mishra, the TPACK framework is bound to culture and context (Mishra & Warr, 2021). Thus, the association between the synthetic variables of knowledge and affection and that of each of their components was critical to be investigated, especially within the cultural context of

Ethiopia in which the interest to become a teacher is either declining or considered a last choice, and the value of teachers reticent.

As presented in Table 2, Content, Pedagogy, and Technology are correlated with each other with the highest mean values of PCK and PK and smaller standard deviation. Thus, it is useful to deliberately work to associate content, pedagogy, and technology in teacher education programs, given that they are positively strongly correlated. According to Mishra and Koehler (2006), a teacher who can navigate between these interrelations acts as an expert who is different from a sole subject matter or pedagogy expert. Thus, paying attention to integrating these would add value to enhancing the peculiarities of PK and PCK which are useful for teaching specific content, and making the preservice trainees competent. As learners these days are technology natives, seeking a mechanism of integrating the three pillars of learning: content, pedagogy, and technology is more vital than presenting content and pedagogy separately. Designing courses that integrate content, pedagogy, and technology requires reviewing the existing courses and their delivery.

Though integrating content, pedagogy, and technology was found to be essential, nothing will be successful unless preservice teachers have positive psychological readiness, motivation, and interest to be successful learners who love the profession of teaching. As presented in Table 3, the three components of affect: motivation, engagement, and perception were found to be statistically significant in their association. Students who were motivated were the ones who equally had better engagement. Equally, the students who had better engagement were found to have better perceptions towards becoming a mathematics teacher $r(445)=.61$, $p<.001$ which can be taken as one indicator for enhanced professional competence. According to Davis et al (2009), the sorts of factors that tend to be identified as significant in discussions and studies of mathematics teacher development are focused on teachers themselves, including, for example, their beliefs about learning, their experiences with mathematics, and their attitude towards formal education. Enhancing positive motivation, as depicted above enhances engagement and perceptions which are useful in developing competence and the teaching profession. According to Bergmark et al. (2018), organizing teacher education programs drawing on multiple motives, which are expected to contribute positively to the completion of teacher education and teacher retention in future professions is important. Hence, addressing the affective issues of becoming a teacher in general and a mathematics teacher, in particular, is of primal importance that needs to be accounted for with cognitive developments in teacher education.

From the result presented in Table 4, all the knowledge domain subcomponents are significantly correlated with engagement, perception, and motivation. Those that are significantly correlated with positive motivation are PCK, PK, and CK in order of their strength. This shows the useful position of integrating content and pedagogy in teacher education programs.

From Table 4, one observes that integrating CK and PK is apparent and needs to be addressed. This is so because teachers' views, understanding, and practice evolve from their education and training but Ball et al., (2005) state subject matter knowledge – not only knowledge of the actual topics teachers teach but the special forms of mathematical knowledge that are particular to the profession of teaching are needed. Equally, Turunklu and Yesildere (2007) stated that "if teachers do not know how to translate …[mathematical] abstractions into a form that enables learners to relate the mathematics to what extent they already know, they will not learn with understanding" (p.1). Therefore, integrating CK and PK is critical.

Despite the pairwise correlation of each of the components of both the knowledge and affective domains which showed varying degrees of associations, it was imperative to check the aggregate correlation that can be manifested between the knowledge and affective domains with the intent of identifying the common variance that required use of canonical correlation. The result of this canonical correlation is presented in Table 4 with a first factor loading of 37.23%, and this shows the importance of considering the design for joint consideration of knowledge and affect.

Some researchers emphasize the role technological knowledge plays in the competence of teachers (Mishra, 2020; Ramaila & Molwele, 2022). Some say technology enables teachers to rethink and refresh their pedagogy by providing opportunities rather than solutions for issues in mathematics instruction, explaining justified support of technology for pedagogy. Others counter-position this and indicate that merely using technology to replicate traditional lessons is not enough (Landry 2010) and the need to understand how teachers perceive students' use of these connected technologies in the classroom is of paramount importance (Luo & Murray, 2018). Mathematics teaching should maximize the potential of technologies to enrich and transform instruction and to take advantage of these opportunities, educators are required to think, work, and often experiment with technology (Bressoud, 2009). However, teachers generally appreciate the benefits of educational technologies, they often find smooth and effective integration of new educational technologies challenging. Therefore, integrating pedagogy and technology as indicated by the positive relation between PK and TK could enforce teachers' competence. At the TPCK level, however, content, area, and situation are predictor factors that need to be addressed (Mishra, 2020; Tara & Michele, 2008).

From Table 4, all canonical correlations that include the two variable sets (knowledge and affect) have a relationship with the r2 type effect size of .418 which indicates that the full model explained a substantial portion, about 42% of the variance shared between the two variable sets. In addition, the criterion variable set in function 1, positive engagement, positive motivation, and positive perception were the primary contributors to the criterion synthetic variable. Thus, focusing on TPCK that improves positive motivation, engagement, and perception is critically important in teacher education. The results tell us that if an effort is deployed towards PCK, PK, CK, and TPCK Factor 1 (the ability to operate technology) in their order of importance the future teachers will have better competence after graduation. In the Ethiopian context, however, Aklilu, and his colleagues, reported that:

> *we still have people who forcefully argue that the core of teacher education programs should be equipping prospective teachers with strong subject matter knowledge. Such people assume implicitly or explicitly that once the teacher has mastery of the subject matter, presentation of it will take care of itself* (Aklilu, et al. 2008, p. 23).

This saying goes without doubt that content knowledge alone is sufficient, but the finding of this Study challenges the primacy of the view towards the sufficiency of CK only. It calls for the consideration of the TPCK framework for knowledge development and boosting positive motivation, engagement, and perception so that preservice teachers will benefit from teacher education to be competent teachers and professionals. These results were supportive of the theoretically expected relationships between knowledge domains and affective domains, and the importance of each. In this regard, the affective side is thought to be among the most important qualities teachers should have (Cubuku, 2010) since teachers are more likely to exhibit more enthusiasm in the preparation and presentation of lessons when they are affectionate towards learners (Sandt, 2007), and tend to continuously engage in their professional development. The integration of technology in the classroom, however, needs to be practice-focused rather than techno-centrist tool-focused that persists in the system (Zinger, et al., 2017). Hence, the joint consideration of knowledge – integrating content, pedagogy, and technology and affect – integrating positive motivation, engagement, and perception is critical to produce competent future teachers, and these need to be considered in the reform efforts of teacher education programs. These also indicate both the direct and indirect impacts of strengthening the joint consideration of knowledge and affective dimensions on the selection of preservice teachers, the teaching-learning process in teacher education, and that of professional competence upon graduation. Sharma et al. (2008) and Kulgemeyer and Riese (2018) claimed that an emphasis on effective teaching strategies that improve both knowledge and attitude might also contribute to decreasing preservice teachers' concerns and foster their positive attitudes, and positive influence of the knowledge components they acquired in academic teacher education and on their teaching quality. Reviewing existing teacher education programs and curricula alongside such integration could also be one important implication. Ensuring the professional competence of preservice teachers shall also have far-reaching implications on student learning at schools.

Conclusion

Since both knowledge and affective domains were independently and synthetically correlated, and about 42% of the variance was shared between the two variable sets jointly considering these in teacher education is critically important, if not mandatory. Addressing an improvement of 42% of the variance through the joint consideration would also have reverberating impact on the teacher education program, and the quality of teaching-learning at schools where these preservice teachers would teach.

Recommendations

The following recommendations have been forwarded in relation to each specific research question.

- Since PCK, PK, CK, and TPCK factor 1 were found to have a strong impact on both affect and overall competence of would be teachers in their order of presentation, it is necessary to devise a mechanism for building the capacity of teacher educators to fulfill the demands for PCK, PK, CK and TPCK and supply of resources so that preservice teachers could benefit during their stay in the teacher education programs.

- Since there was a strong correlation between knowledge and affective constructs, it would be good for concerned authorities to pay maximum attention to integrating both to impact the professional competence of preservice teachers.
- Since 42% of the variance was shared between the two variable sets of knowledge and affect, it is advisable to consider both jointly to bring a positive effect on teacher education which shall have an impact on both the preservice teachers and students at schools whom these preservice teachers would teach.

Limitation of the Study

The Study was cross-sectional where data was collected at one point in time. For generalizability, it may need mining more data and doing analysis. It is also based only on a sample of available graduating preservice teachers because of which it may lack the views of those who are at the beginning or in the middle of the teacher education program. Considering those may have contributed to a better conclusion.

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