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TECHNO-PEDAGOGICAL CONTENT KNOWLEDGE OF UNDERGRADUATE PRESERVICE TEACHERS MAJORING IN BIOLOGY BASED ON THEIR DEMOGRAPHIC VARIABLES IN TANZANIA

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ABSTRACT

This study was designed to examine Techno-pedagogical Content Knowledge of Preservice Undergraduate Preservice Teachers based on their demographic Variables in Tanzania. Basically, the study investigated perceptions Sokoine University of Agriculture teacher students on their knowledge with regards to the integration of ICT in their instructional practices. Descriptive, comparative and correlational analyzes were carried out using SPSS version 23. The non-probabilistic sample consisted of 404 Preservice Undergraduate Preservice Teachers from the Sokoine University of Agriculture in Tanzania. A recently constructed TPACK tool by Paidican (2019) was used as a data collection instrument. The results show that preservice teachers had higher levels of pedagogical and content knowledge compared to technology knowledge. Female prospective teachers showed higher levels of knowledge in the Technological Knowledge, Pedagogical Knowledge and Content Knowledge subscales. In addition, a positive correlation between the variables studied was confirmed. The analysis of the results showed that the prospective teachers appear to believe that they have a good level of knowledge with regards to the TPACK domains, i.e., content, pedagogy and technology. However, most teachers perceived themselves as not able to integrate their TPACK knowledge in order to design and implement meaningful ICT-based interventions in their classroom. Statistically significant differences were also recorded in relation to teachers' factors, i.e., sex, years in the University and their subjects in education.

KEYWORDS: Knowledge of teachers, educational technology, Technology, Pedagogy and Content Knowledge, and Integration of technology

INTRODUCTION

Although it might be argued that teachers should be subject matter experts, they should also be able to demonstrate a mastery of the teaching strategies that would aid students in understanding the topics. The term pedagogical content knowledge refers to this instructor ability in both pedagogy and the subject matter. As first defined by Shulman in 1987, pedagogical content knowledge (PCK) is the blend of instructors' subject-matter expertise with their pedagogical knowledge. The teaching

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profession's values and methods serve as the foundation for pedagogical content knowledge. It also includes conceptual and procedural knowledge, a repertoire of different techniques or activities that accommodate various learning preferences or styles, knowledge of techniques for assessing and evaluating, and knowledge of a variety of easily accessible resources that can be used in the classroom. Empirical studies show that teachers' content knowledge must blend with knowledge of how learners respond to content (PCK). For example, Coe et al. (2014) identify strong evidence that PCK is a key element in effective teaching.

The current developments in technology has also begun to change the roles of teachers and learners in curriculum and teaching. As a result, experts in education have added technology as another component in addition to the pedagogical content knowledge. In 2006, the Technology, Pedagogy, and Content Knowledge (TPACK) model was developed by Mishra and Koehler. Based in Shulman's (1987) idea of Pedagogical Content Knowledge, Technological Pedagogical Content Knowledge (TPACK) has emerged as a useful frame for describing and understanding the goals for technology use especially in preservice teacher education. This model attempts to identify the nature of knowledge required by teachers for technology integration in their teaching, while addressing the complex and varied nature of teacher knowledge (Mishra and Koehler, 2006). This model require teachers to learn several skills relating to subject matter, pedagogy, and cutting-edge technologies. The TPACK framework by Mishra and Koehler (2006) is an extension of Shulman's (1987) Pedagogical Content Knowledge (PCK).

In the twenty-first century, technology plays a significant role as a tool to assist teachers in delivering lessons and students in learning. Inclusion of technology transformed the concept of PCK, to TPACK (Technology, Pedagogy Content Knowledge, and TPACK). Effective technology integration for teaching a certain subject matter requires developing sensitivity to the dynamic, transactional relationship between knowledge components placed in specific situations. Every situation is different because of the particular teachers engaged, the grade level, school-specific problems, demographics, cultures, and other factors. There is no one set of content, technology, or pedagogy that will be effective for all teachers. The technological pedagogical content knowledge (TPACK) framework and educational research both emphasize the importance of context (Rosenberg & Koehler, 2015). The interaction of the three basic types of knowledge Content Knowledge (CK), Pedagogy Knowledge (PK), and Technology Knowledge is at the core of the TPACK system (TK). These three knowledge bases are not seen in isolation by the TPACK strategy. Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge are the four main forms of knowledge that are highlighted in the TPACK framework (TPACK) as seen in Figure 1.

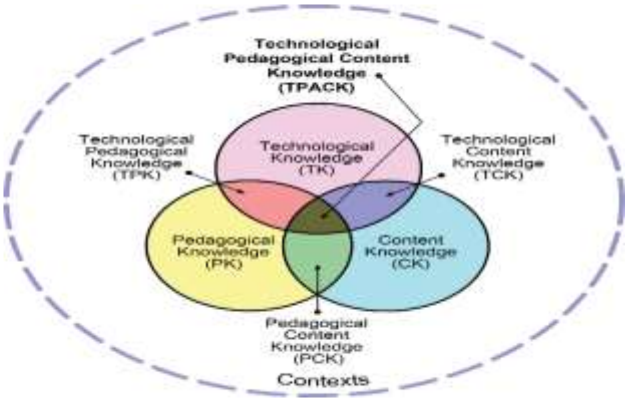

Fig. 1 - Illustration of the Technological Knowledge of Pedagogical Contents (Source: http://tpack.org)

TPACK is a now a term widely used to describe what teachers need to know in order to effectively integrate technology into their teaching. The sub dimensions that make up TPACK can be identified and defined as follows:

1. Technological Knowledge (TK): These are teacher skills related to the use of Information and communications technology (ICT) technologies including computers, projectors, cameras, digital movies, blackboards, the Internet, and the ability to use various software packages (Koehler et al., 2014; Munyengabe et al., 2017). Technological knowledge (TK) enables teachers to not only understand the role of information technology, but also to apply it properly, be able to identify useful technologies, and adapt to changes in technology happening word wide (Koehler & Mishra, 2008).Technology is an effective tool that may assist and improve education in a variety of ways, from making it simpler for teachers to generate instructional materials to opening up new avenues for individual and group learning (Schmidt et al., 2009)The Internet's global reach and the availability of smart gadgets that can connect to it have ushered a new era of education.
2. Content Knowledge (CK): These are teacher competencies associated with the subject matter to be taught. It is important to note that teachers who offer knowledge in relevant contexts are more likely to have successful teaching and learning outcomes (Mishra and Koehler, 2006; Munyengabe et al., 2017). It is the core knowledge applied in identifying, comprehending, and resolving content issues that arise during subject-matter teaching.
3. Pedagogical Knowledge (PC): Teachers must be knowledgeable about teaching-learning processes, which should involve managing classrooms, designing lessons, and evaluating those processes (Munyengabe et al., 2017; Schmidt et al., 2009). It refers to the techniques and procedures of instruction and encompasses knowledge in student learning, evaluation, lesson planning, and classroom management.
4. Pedagogical Content Knowledge (PCK): occurs at the point when CK and PK intersect; in the teaching process, the PCK prepares the CK in this approach (Munyengabe et al., 2017; Koelher et

al., 2014). Since it combines both pedagogy and content with the aim of improving teaching methods in the content areas, pedagogical content knowledge varies for different subject areas.

5. Technological Content Knowledge (TCK): Technological content knowledge is the understanding of the different ways that technology can represent different types of material. It implies that educators are aware of the ability they have to alter how students practice and comprehend a particular subject's concepts by utilizing a particular technology. It is a product of the TK and CK; the TCK relates to how technology presents particular content (Koelher et al., 2014; Munyengabe et al., 2017; Schmidt et al., 2009).
6. Technological Pedagogical Knowledge (TPK): refers to understanding how various technologies can be used in teaching and how employing technology may transform how teachers teach. The TPK, which is the outcome of combining TK and PK, refers to this understanding of how different technologies can be employed and how teachers present the subject (Mishra & Koehler, 2006; Munyengabe et al., 2017; Schmidt et al., 2009).
7. Technological Pedagogical Content Knowledge (TPACK): represents the knowledge that instructors need to have in order to integrate ICT in the teaching and learning process, and it corresponds to the intersection of the CK, PK, and TK (Koehler et al., 2014; Munyengabe et al., 2017; Schmidt et al., 2009).

The TPACK framework concentrates on developing and accessing teacher expertise that is focused on efficient student learning across a range of curriculum areas (Schmidt et al., 2009). As a result, TPACK is a valuable framework for considering what knowledge teachers should possess and potential paths for acquiring it. The kind of training and professional development experiences created for both preservice and in-service teachers may be impacted by using TPACK as a framework for assessing teaching knowledge. As a result, there is a constant need to reconsider how we educate teachers for the classroom and suggest innovative approaches that better prepare instructors for successfully integrating technology into their instruction.

Problem statement

One form of knowledge framework that teachers must have in order to be actualized in learning is Technological Pedagogical and Content Knowledge (TPACK). The integration of technology in learning is considered important in response to the challenges of globalization era marked by the rapid development of information and communication technology. Technology can help teachers in developing their professionals. The presence of the internet can encourage, teachers look for the latest issues on education, learning strategies and the development of science. However, to ensure that students receive a high-quality education, teachers must be experts in technological pedagogical content knowledge (TPACK). Thus, it is essential to examine how well-versed in TPACK Tanzanian prospective instructors are in order to give policymakers and other academics a starting point for comparison. The TPACK tool was prepared to apply what they prospective teachers had learned over their three years in the University while gaining the requisite knowledge. In addition, there aren't any research that show a connection between the TPACK's dimensions and demographic elements like

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sex, years in the university education and their major subjects in Tanzania. Considering the status of their years of university education, sex, and subject majors, this study sought to assess the mastery of TPACK, in particular among biology preservice teachers.

OBJECTIVES OF THE STUDY

i. Examine the levels of technical, pedagogical and Content Knowledge of undergraduate preservice teachers majoring in Biology at Sokoine University of Agriculture (SUA)

ii. Find out whether the levels of technical, pedagogical and content Knowledge of undergraduate preservice teachers statistically differs based on their demographic Variables of sex, subject majors and year of university education.

METHODOLOGY

Study Area

This study involved prospective Biology teachers studying in the Sokoine University of Agriculture (SUA). This University is located in Morogoro Municipality, Tanzania, and has 3,350 ha of land for training, research and production in Morogoro Municipality. The university has three sets of preservice teachers who have Biology as one of their major subjects. These are those with Biology and Chemistry (CB), Biology and Geography (GB) and those with Biology and Agricultural Science (BA).

Sample Size

The study was carried out through a quantitative, non-experimental, descriptive, comparative and correlational design. The sample consisted of second and third years preservice teachers of the Sokoine University of Agriculture majoring in Biology of the academic year 2021/22. The sample was selected for convenience or intentional. The sample consisted of 404 undergraduate preservice teachers majoring in Biology at Sokoine University of Agriculture in Tanzania. In terms of sex, the sample was made up of 189(46.7%) female and 215 (53.3%) male students. Regarding the years of study in the University, the sample had 210 (52%) Biology education students and 194 (48%) finalist students majoring in Biology. In terms of programme enrolled, the sample had 135 (33.4%) Biology with Agriculture students, 144 (35.6%) Biology with Chemistry students and 125 (25%) students majoring in Biology and Geography respectively as summarized in table 1 below.

Table 1: Sample characteristics

	Second year		Third year		Total
	Male	Female	Male	Female	
Biology with Agriculture (BA)	42	32	31	30	135
Biology with Chemistry (BC)	43	40	34	27	144
Biology with Geography (BG	27	26	38	34	125
Total	112	98	103	91	404
	210		194		

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Instrument

TPACK questionnaire by Paidican (2019), whose reliability according to Cronbach `s Alpha coefficient is 0.948 was used as a data collection tool. The questionnaire has 40 items on a five-point Likert scale that are connected to the central dimensions and the several interactions that make up the TPACK model: Strongly disagree (1), Disagree (2), Neither disagree nor agree (3), Agree (4), and Strongly agree (5). The internal consistency dependability (coefficient alpha) for the seven TPACK subscales ranged from.75 to.92. This range is regarded as being adequate to exceptional by George and Mallery (2001). A number of 1 is awarded to strongly disagree responses to questions, and a value of 5 is assigned to strongly agree responses. Disagree response is awarded 2, neither disagree nor agree is awarded 3 while 4 is for Agree responses. For each construct the participant's responses are averaged to have their mean. For example, the 6 items under TK (Technology Knowledge) are averaged to produce one TK (Technology Knowledge) score of participants.

Administration and data collection

Data collection in Morogoro was between March and June 2022. Google Forms was used to disseminate the questionnaire in both paper and electronic form. Before performing the statistical analysis, a descriptive analysis of the data was carried out. Descriptive techniques included constructing tables of means, measures of dispersion such as variance or standard deviation. Independent samples t-test was used to examine whether there is sex-based dominance in the TPACK subdimensions. In addition, the linear coefficient by Pearson was used to ascertain the relationship between the different demographic variables. The data were gathered, organized, and analyzed using SPPS Statistics, version 23 for Windows, a statistical application for the social science studies.

RESULTS

Descriptive analysis of the TPACK model

The first objective of this study was to measure the levels of technical, pedagogical and Content Knowledge of undergraduate preservice teachers majoring in Biology at Sokoine University of Agriculture. The arithmetic mean, standard deviation, and ranking statistics were addressed during the analysis of the TPACK subscales. Table 2 summarizes the finding of this objective. The TPACK questionnaire's overall average was (M =3.47; SD=0.621). The highest scores were on Pedagogical Knowledge (M = 4.11 & SD = 0.68) and Content Knowledge (M = 4.02 & SD = 0.70). In contrast, TK's arithmetic mean was the lowest with total M=3.57 and standard deviation (SD) of 0.71.

Table 2 - Means, standard deviation and ranking of TPACK knowledge.

Types of Knowledge	Half	Standard deviation	Ranking
Technological Knowledge (TK)	3.52	0.796	7
Pedagogical Knowledge (PK)	4.28	0.724	1
Content Knowledge (CK)	4.11	0.716	2
Pedagogical Content Knowledge (PCK)	4.02	0.793	3
Technological Content Knowledge (TCK)	3.73	0.836	6
Technological Pedagogical Knowledge (TPK)	3.90	0.766	4
Technological Pedagogical Content Knowledge (TPACK)	3.87	0.878	5
TOTAL	3.98	0.643	

These findings suggest that Biology pre service teachers in Tanzania still have room for technological development. It is advised that further action be taken in order to enhance their' technological proficiency, in addition to the currently compulsory training programs. The study's showed that teacher preparation programs and actual classrooms differed in how they integrated technology into teaching

Students' knowledge by specific TPACK subdivisions

The study also sought to examine knowledge of sampled students' in each specific TPACK subdivisions. Hence, all of the items in the Paidican (2019) TPACK tool were analyzed and summarized in the series of Tables from 3.1 to 3.7.

i. Technological Knowledge (TK)

Teachers are supposed to possess the knowledge necessary to effectively use and implement technology during teaching. In this study, the level of respondents' technological knowledge is displayed in Table 3.1. The findings indicates that the prospective teachers' in Tanzania significantly emphases on using new technologies in teaching with a mean of 3.79. Item number 5 on whether participant know many different ICT resources and tools had the lowest mean of 3.40. Both the highest and lowest means can be verbally translated as "strong knowledge." The pre-service teachers' overall weighted mean for technology knowledge is 3.70. However, this value can still be interpreted as strong knowledge.

Table 3.1 - Means and standard deviation of Technological Knowledge (TK) items.

items	Half	Standard deviation
1.Technological Knowledge (TK)		
1 I know how to solve my technical problems with ICT	3.77	1.015
2 I assimilate ICT knowledge easily	3.92	0.935
3 I keep up to date on the most important ICT	3.63	0.971
4 I often play games and experiment with the use of ICT	3.35	1.065
5 I know many different ICT resources and tools	3.40	1.002
6 I have the technical knowledge I need to use the TIC	3.55	1.036
7 I have had enough opportunities to work with the different ICT resources and tools	3.36	1.074
		1.037

Source: Field survey (2022)

Information and communication technology (ICT) is being increasingly used in teaching and learning in today's society (Ghora & Bhatti, 2016). Today, University students need basic computer skills just as much as other courses (Sharma, 2018). Students' awareness of how to think more effectively and creatively about their lectures has risen due to ICT-based activities. The pre-service teachers' exposure to a variety of ICT-based activities during their academic careers and daily activities helped them develop strong technology knowledge skills. Ghora and Bhati (2016) noted that technological expertise is clearly one of the pillars for ICT integration, and that improving teachers' technology proficiency enhances the possibility of them implementing ICT.

ii. Content Knowledge (CK)

Teachers must have a thorough understanding of the subject matter in order to help students develop cognitive maps, relate thoughts, and resolve misconceptions. Table 3.2 details the Content Knowledge (CK) of the pre-service Biology teachers in Tanzania. The highest mean is 3.75, and is to the item asking respondents whether they have sufficient knowledge about their subject of Biology. The item asking prospective teachers whether familiar with recent researches of the subject got the lowest mean of 3.36. Although this mean is also interpreted as strong knowledge as well. With the weighted mean of 3.57, the pre-service teachers “have strong knowledge” in content knowledge.

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Table 3.2 - Means and standard deviation of Content Knowledge (CK) items.

items	**Half**	**Standard deviation**
2. Content Knowledge (CK)		
2.1 I have sufficient knowledge about my own discipline and how it is taught	4.17	0.890
2.2 I have sufficient knowledge of the current *curriculum* of my discipline and the use of curricular instruments	4.20	0.816
2.3 I have the ability to design, plan and implement learning experiences in my own discipline	4.32	0.838
2.4 I know how to improve my students' reading comprehension so that they are frequent and thoughtful readers	4.01	0.838
2.5 I know how to enhance the understanding and taste for reading literary texts in my students	4.01	0.897
2.6 I understand the importance and I know how to promote the understanding of multimodal texts in my students	4.01	0.913
2.7 I know how to stimulate quality written and oral production in my students	4.01	0.944

Source: Field survey (2022)

Teachers are supposed to use their subject matter expertise to better organize and utilize content information for their students to understand (Heggart, 2016). Teachers must have a solid understanding of their subject matter in order to adapt to the demands of each classroom, identify pupils who are having difficulty, and modify their delivery of the material in order to make it clearer. The findings in this study indicates that prospective Biology teachers in Tanzania have the feelings that they are good in content knowledge.

iii. Pedagogical Knowledge (PK)

Pedagogical knowledge refers to the specialized knowledge of teachers for creating effective teaching and learning environments for all students. Table 3.3 summarizes Pedagogical Knowledge of the Biology Prospective Biology teachers in Tanzania. The question on whether the respondent is prepared to promote the personal and social development of their students scored the highest mean of 4.30 while the lowest mean of 3.99 is for the item assessing whether respondents is prepared to deal with diversity and promote integration in the classroom. Other items that received lower means include the one which assessed whether respondents are aware that they must learn and reflect continuously (M=4.01) and the one asking whether prospective teachers know how school culture is generated (M=4.01)

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Table 3.3- Means and standard deviation of Pedagogical Knowledge (PK) items

items	Half	Standard deviation
3. Pedagogical Knowledge (PK)		
3.1 I know my students and I know how they learn	4.16	0.826
3.2 I am prepared to promote the personal and social development of my students	4.30	0.832
3.3 I know how to design and implement learning strategies, appropriate to the learning objectives and according to the context	4.26	0.817
3.4 I am prepared to manage the class and create an appropriate environment for learning according to its context	4.24	0.829
3.5 I know and apply evaluation methods to observe the progress of my students and use the results to provide feedback on learning.	4.10	0.806
3.6 I know how school culture is generated	4.01	0.801
3.7 I am prepared to deal with diversity and promote integration in the classroom	3.99	0.819
3.8 I am aware that I must learn and reflect continuously	4.01	0.805

Source: Field survey (2022)

iv. Pedagogical content knowledge (PCK).

PCK describes how teachers' mastery of the content should be conveyed to the targeted students. Pedagogy provides strategies to what teachers know. Table 3.4 summarizes Pedagogical Content Knowledge of the Biology Prospective teachers at Sokoine University of Agriculture in Tanzania. The question on whether the respondent knows how to guide students on content-related problem solving in groups scored the highest mean of 4.03 while the lowest mean of 3.67 is for the item assessing whether respondents knows how to guide students' reflective thinking in the discipline he/she is teaching. Teacher education programs should blend these two knowledge bases to better educate teachers, whether from a pedagogical or content standpoint. It can clarify how pedagogy and instructional process components should be combined with content knowledge. The implementation of teachers' topic expertise and pedagogy is required in all levels of institutions' teacher preparation programs.

Table 3.4 - Means and standard deviation of Pedagogical Knowledge (PCK) items.

Items	Half	Standard deviation
4. Pedagogical Content Knowledge (PCK)		
4.1 I can select teaching approaches effectively to guide students' thinking and learning in reading	4.03	0.825
4.2 I can select teaching approaches effectively to guide students' thinking and learning in writing	3.67	0.893
4.3 I can select teaching approaches effectively to guide student thinking and learning in my own discipline	4.11	0.849

Source: Field survey (2022)

v. Technological Content Knowledge (TCK)

ICT proficiency is a requirement for all educators in the twenty-first century. The classroom is being revolutionized by combining teachers' subject-matter expertise with technology. The use of technology in teaching and learning is significant. Numerous research have shown how using technology enhances learning. Table 3.5 below summarizes Technology Content Knowledge (TCK) of pre-service teachers at Sokoine University of Agriculture Tanzania. The items with the greatest mean, "knows ICT-applications that can be used to better understand the contents of the subject," and the lowest mean, "knows websites with online materials for studying the subject area," both contain the interpretation "have strong knowledge." The pre-service teachers "have strong knowledge" of technology content, according to the overall weighted average of 3.56.

Table 3.5 - Means and standard deviation of Technological Content Knowledge (TCK) items.

Items	Half	Standard deviation
5. Technological Content Knowledge (PCK)		
5.1 I know technologies that I can use to understand and elaborate content about reading	3.50	0.929
5.2 I know technologies that I can use to understand and elaborate content on writing	3.72	0.886
5.3 I know technologies that I can use to understand and create content about my own discipline	3.42	0.879

Source: Field survey (2022)

The item that got the highest mean of 3.72 assess whether the candidate knows technologies that he/she can use to understand and create content about their discipline and the item with the lowest mean of 3.42 states, “know technologies that I can use to understand and create content about my own

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discipline”. However, with a general weighted average of 3.56, this means Biology pre-service teachers in Tanzania "have strong knowledge" of technology content. Teachers should prepare themselves with technical knowledge and proficiency and use technology to improve the teaching and learning process (Kasim & Singh, 2017). Due to the demands of the 21st century learning environment, Kasim and Singh stressed how important it is for those student instructors to understand how to use digital tools in the classroom. Future teachers will face a challenge since students are heavily exposed to a range of technological tools, which will make it difficult for them to understand how to teach them. The current study shows that both in the pre- and post-course surveys, in-service instructors had the lowest level of confidence in their technological content knowledge (TCK). The findings from this study corresponds with those by Lehiste (2015), which found the lowest degree of confidence of students in their TCK and CK.

vi. Technological Pedagogical Knowledge (TPK)

One of the major responsibilities of an instructor is on how student learning can be effective. In the world of rapidly growing technology, it is a challenge to every instructor to integrate technology in the delivery of their lessons. Table 3.6 summarizes Technology Pedagogy Knowledge (TPK) of the prospective Biology teachers at Sokoine University of Agriculture. The questions which assed students on whether they know how to select technologies that improve approaches for a class and the highest mean of 3.87. On the other hand the item on their opinions that their training as a teacher has made me think more carefully about how ICT can influence the teaching approaches, I use in the classroom. Questions on how to use ICT in teaching as a tool for students’ reflective thinking and how to use ICT in teaching as a tool for students to plan their own learning,” also got the lower mean of 3.66.

Table 3.6 Means and standard deviation of Technological Pedagogical Knowledge (TPK)

items	**Half**	**Standard deviation**
6. Technological Pedagogical Knowledge (TPK)		
I know how to select technologies that improve approaches teachers for a class	3.87	0.883
6.2 I know how to select technologies that improve student learning in a class	3.49	0.862
6.3 My training as a teacher has made me think more carefully about how ICT can influence the teaching approaches, I use in the classroom	3.04	0.903
6.4 I adopt critical thinking about how to use the ICT in the classroom	3.69	0.974
6.5 I can adapt the use of ICT on which I am learning in the different teaching activities	3.60	0.911

Source: Field survey (2022)

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With a general weighted mean of 3.71, pre-service teachers "had strong knowledge" of technology pedagogy (TPK). Technology and pedagogical practices must be thoughtfully integrated during lesson preparation if ICT is to be used successfully in the classroom (Janssen, Knoef, & Lazonder, 2019). The critical limitation in creating pre-service teacher training programs that encourage teachers to elaborate on the learning opportunities that ICT can bring to students is to do so in a way that fosters reflection, collaboration, and dialogue (Sointu et al., 2016).

vii. Technological Pedagogical Content Knowledge (TPACK) items

The educational approach known as "Pedagogy and Content Knowledge" is centered on how technology is used to integrate learning into teacher preparation. Every teacher in the modern educational era should have TPACK, which is the perfect representation. The use of TPACK in the classroom is depicted in Table 3.7. The findings show an improvement in knowledge across nearly all TPACK domains. Based on the overall mean of 3.60, practice teachers demonstrated high knowledge in implementing TPACK in the classroom. The skill of using ICT to facilitate group thought and idea sharing while teaching the subject resulted in the highest mean, which is 3.82. Teachers who work with pupils whose lives are increasingly focused on the web must improve both the collaborative working environment and their ICT proficiency (Patel & Thakkar, 2017). However, according to Garcia-Valcárcel and Mena (2016), teachers believe that ICT generally makes it easier for them to collaborate with students. However, their actual use of ICT is only moderate. Knowing how to use ICT as a tool for students' reflective thinking in the subject's teaching comes in second with a score of 3.66. Additionally, using the reflection technique as a blended learning model may be a useful strategy to raise students' thinking capacities and encourage introspective and in-depth thinking. The lowest mean, 3.60, was achieved by knowing how to use ICT in education as a tool for students' critical thinking, although this still translates to "has a high knowledge." In order to develop the 4Cs and comprehend how learning occurs, information and communication technologies must be used. But merely utilizing technology does not ensure that deep learning will take place. To function in a transformative setting, the usage of technology needs to be compatible with and flexible enough to accommodate the knowledge of learning (Serdyukov, 2017). It was clear that the PSTs had a good attitude toward TPACK and that they were excited about the chance to increase their understanding of and proficiency with technology integration (Redmond & Lock, 2019).

Table 3.7 Technological Pedagogical Content Knowledge (TPACK) items

items	Half	Standard deviation
7. Technological Pedagogical Content Knowledge (TPACK)		
7.1 I can teach classes that adequately combine reading, the use of ICT and teaching approaches	3.82	1.048
7.2 I can teach classes that adequately combine my own discipline, the use of ICT and teaching approaches	3.70	1.064
7.3 I can teach classes that adequately combine my own discipline, the use of ICT and teaching approaches	3.45	0.917
7.4 I know how to select the ICTs to use in the classroom that improve the content I teach, the way it is taught and what the students learn	3.41	0.952
7.5 I know how to use my teaching materials and resources for the classroom, as well as the strategies that combine content, ICT and teaching approaches that I have learned about	3.49	0.957
7.6 I can guide and help other people to coordinate the use of content, ICT and teaching approaches in the educational unit where I work	3.40	0.994
7.7 I can select the ICTs that improve the content of the classes.	3.44	0.987

Source: Field survey (2022)

Regarding the findings in Table 3.7, it was noticed that the means, which range from 3.35 (item 1.4) to 3.82, are higher than the instrument's mean (M total = 2.5). Additionally, the PK sub dimension's items with the highest scores mainly fall under this heading: 3.8; M total = 4.61; item I am aware that I must always think and research (item 3.2; M total=4.38). "I am prepared to foster my students' social and personal development" (item 3.4; M total=4.34) In accordance with the context of the class, "I am prepared to oversee the group and create a supportive learning environment" (item 2.3; M total=4.32) Item 3.1 (M total = 4.26): "I can create, plan, and implement learning activities in my own discipline." I am aware of my students' learning strategies and (item 3.3: M total= 4.26) “I am able to design and implement learning strategies that are suitable for the circumstances and the learning goals.

All of the items with the lowest averages were from the TK sub dimension: 1.5 item, M total = 3.35 "I often use ICT to play games and do exams" (item 1.6; M total=3.45) I am knowledgeable about a range of ICT technologies and resources; (item 1.7; M total 3.26) The items all make the claims, "I have enough experience working with the various ICT resources and tools," "I have the technical abilities I need to use ICT," and "I stay up with the most important ICTs." "I have plenty of chances to work with different ICT tools and resources."

Comparative analysis of TPACK based on some selected demographic variables

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Another objective of this study was to find out whether the levels of technical, pedagogical and content Knowledge of undergraduate preservice teachers statistically differs based on their demographic Variables of sex, level of degrees and year of University education. The TPACK subscales arithmetic means underwent descriptive analyses so that potential differences based on covariates (sex, year in the university, and level of degree) could be investigated. T-tests for independent samples were also carried out. To compare the TPACK subscales in men and women, the t-test for independents samples was used as summarized in Table 4. Females (M= 4.12; SD= 0.703) and males (M= 3.87; SD= 0.72) showed statistically significant differences in Content Knowledge (CK); t(353) = 2.119, p= 0.014. The findings showed that the women demonstrated a higher level of expertise in their particular field than the men. There were no notable statistical differences in the remaining TPACK subscales.

Table 4 - Means, standard deviation and t-test for independent samples according to gender.

TPACK Subscale	Male		Female		T-test	
	M	SD	M	SD	T(353)	p
TK	3.44	0.77	3.53	0.78	-.831	0.343
CK	4.06	0.71	3.87	0.71	1.419	0.014
PK	4.20	0.72	4.15	0.61	0.451	0.483
PCK	3.92	0.75	4.01	0.62	0.060	0.852
TCK	3.65	0.83	3.58	0.73	0.606	0.481
TPK	3.80	0.69	3.78	0.68	0.152	0.771
TPACK	3.81	0.82	3.59	0.65	1.125	0.223

Source: Field survey (2022)

The TPACK sub dimensions based their years in the University education were compared. The study involved 210 second year students and 194 third year biology students. There were statistically significant differences in Technological Knowledge (TK) in teachers in favour of third year Biology students (M= 3.82; SD= 0.82); t (355) = 2.199, p= 0.029 as seen in table 5. The result suggests that teachers in their final year (third year) presented greater TK knowledge, which tends to favor the development of ICT-mediated teaching and learning activities, compared to teachers in their second year of university education. In the rest of the TPACK subscales, no significant statistical differences were found between the two groups.

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Table 5 - Means, standard deviation and t-test for independent samples based on their years of university education

Variable	Second year		Final year		T-test	
TPACK Subscale	**M**	**SD**	**M**	**SD**	**T(353)**	**p**
TK	3.53	0.78	3.82	0.82	-2.199	0.029
CK	4.09	0.73	4.19	0.49	-0.779	0.437
PK	4.26	0.75	4.43	0.37	-1.430	0.153
PCK	4.00	0.80	4.15	0.66	-1.116	0.265
TCK	3.71	0.83	3.92	0.83	-1.527	0.128
TPK	3.88	0.76	4.02	0.76	-1.123	0.262
TPACK	3.86	0.88	3.94	0.82	-0.557	0.578

Source: Field survey (2022)

Relationship between the different TPACK subscales

The existence of correlations between the TPACK's dimensions was investigated using Pearson's linear correlation coefficient r. as seen in seen in Table 6. There was a significant positive connection between the variables CK and PK (r=0.744), TCK and TPACK (r=0.731), and TPK and TPACK (r=0.838). Additionally, it was shown that TK had significant positive relationships with the following three variables: TK and TPK (r=0.736), TK and TPACK (r=0.711), and TK and TCK (r=0.617). Increases in TPACK, TPACK, and TCK knowledge are correlated with increases in TK. TK and CK have positive correlations with each other, but they are weaker than those between TK and PK (r=0.480) in the key dimensions that make up TPACK.

Table 6 Correlations between the sub dimensions of the TPACK model.

	TK	CK	PK	PCK	TCK	TPK	TPACK
TK	1						
CK	.446**	1					
PK	.510**	.761**	1				
PCK	.354	.707**	.710	1			
TCK	.623**	.553	.526	.544**	1		
TPK	.772**	.480	.602	.491**	.695**	1	
TPACK	.779**	.534**	.606**	.567**	.726**	.866**	1

Note: ** Correlation is significant at the 0.01 level

DISCUSSION

According to the findings, primary school teachers are more knowledgeable about pedagogy and subject matter than they are about technology, which is in line with other research by Paidican (2019), Roussinos & Jimoyiannis (2019), and Schmidt et al (2009). Girls outperform males in terms of technological knowledge (TK) and its interactions with the other dimensions (TK, TCK, TPK, and TPACK), which is in line with studies by Roig-Vila et al. (2015), Bingimlas (2018), and Schmidt et al (2009). It should be emphasized that caution should be exercised when interpreting data relating to teachers' gender because certain studies have shown that men do better than women in terms of technological knowledge (TK) (Luiket al., 2018 and Schereret al., 2017). Contrarily, there are statistically significant variations in Content Knowledge among women. Contrarily, compared to men, women exhibit statistically significant variations in content knowledge (CK).

With the exception of Content Knowledge, the teaching staff at subsidized private schools perform better in terms of the administrative dependency across the most of the TPACK dimensions (CK). Additionally, statistically significant variations in Pedagogical Content Knowledge were identified (PCK).

Schmidt et al. (2009) questionnaire was administered to 222 pre-service and in-service teachers in Singapore. Lin, Tsai, Chai, and Lee (2013) came to the conclusion that TPACK is strongly related to all other knowledge domains. The same questionnaire was used on 636 computer science teachers by Giannakos, Doukakis, Pappas, Adamopoulos, & Giannopoulou (2015), who discovered a substantial correlation between TPACK sub-domains with high scores.

Regarding education, teachers with a master's degree exhibit better outcomes across all TPACK aspects. Also noted are statistically significant disparities in content knowledge among teachers with master's degrees (CK). It is clear from the correlation analysis's results that there are relationships between the components of TPACK, with the strongest relationships being those between technological pedagogical knowledge (TPK) and technological pedagogical knowledge of content (TPACK), knowledge of the content (CK) and pedagogical knowledge (PK), and technological content knowledge (TCK) and technological pedagogical content knowledge (TPACK).

According to Roig-Vila et al. (2015), technological knowledge (TK), content knowledge (CK), and pedagogical knowledge are the areas with the poorest relationships (PK). In order to enable the results to be generalized, it is necessary in future investigations of probabilistic samples to include teachers from other regions of Chile and to consider the constraints and prospects.

The findings, however are contrary to the study by Pettersson and Näsström (2020) who discovered that Norwegian teachers aged 50 to 59 reported the highest scores in self-efficacy in ICT, and those instructors use ICT tools in their teaching to a greater extent than the other groups.

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