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EXPLORING TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE OF SECONDARY SCHOOL TEACHERS OF SCIENCE SUBJECTS

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ABSTRACT

The 21st century brought a modern education system based on a student-centred approach, while our education system faces challenges in discovering and developing tools for teaching and learning. TPACK is a blend of seven broad constructs; ("TK, PK, CK, TPK, PCK, TCK and TPACK"). This study investigates the science teacher with basic TPACK concepts for teaching science. It covered the teaching experience, age and gender of the participants at the secondary level in the Mirpurkhas division. This study is quantitative method and descriptive with a survey technique. The sample for the study was 172 Science Teachers from Government Secondary Schools in Mirpurkhas. Therefore, a total of 172 participants completed the survey. A survey based on a closed-ended questionnaire was designed as a Likert Scale to collect data from the participants. The researcher used descriptive analysis first to calculate the teachers' degree of TPACK; we collected the data and calculated their frequency, percentage, mean, and standard deviation. Inferential statistics were used to examine the study's hypothesis. The researchers utilized Chi-square tests to examine the difference between the research variables. The results described that the TPACK profile of science teachers was observed well at the secondary level, and gender difference does not exist between the constructs of the TPACK Model, male and female teachers TPACK Profile showed towards TPACK Model. There was a significant difference exist between the experience groups for TPACK Constructs. In contrast, the age difference does not exist between the TPACK constructs except TK, TPK & TPCK. It was found that the teachers are familiar with Technological, Pedagogical & Content Knowledge (TPACK) and want to perform their duties much better in science subjects. Therefore, it is advised that the government make substantial efforts to upgrade school labs and offer internet access so that teachers can train future scientists for the nation.

Keywords: TPACK, Science Teachers, Teaching experience, scientific interest.

INTRODUCTION

The 21st century brought the modern education system, which supports a student-centred approach, but our education system faces challenges in discovering and developing tools for teaching and learning. TPACK is a blend of seven broad constructs: "Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Content Knowledge (TPACK)." TPACK is the growing body of knowledge that covers the main three "core" modules of technology, pedagogy, and content Angeli & Valanides (2009). The TPACK model is a cornerstone for active computer education and demands knowledge of the technology. TPACK is a specialized, highly applied knowledge that supports content-based technology integration. It has been characterized as the multiple intersections of teachers' knowledge of curriculum content, general pedagogies, technologies, and contextual influences upon learning (Koehler & Mishra, 2008) and is only recently starting to be explored in depth regarding teachers' professional learning. TPACK is an extension of Shulman's (1986, 1987) notion of pedagogical content knowledge—the specialized knowledge required to teach differently within different content areas—revolutionizing our understanding of teacher knowledge and its development. The TPACK Model Framework is neutral in terms of technology but also content and pedagogical goals (Mishra & Koehler, 2006). According to (Akturk, A. O., & Ozturk, H. S. 2019), the research that measures TPACK competencies in the associated literature is primarily undertaken before service in teaching, which means that in-service while in service found few teachers teaching. The TPACK study aims to promote technical skills and furnish the in-service science teacher's abilities; therefore, teachers must improve themselves in technology, pedagogy, and content areas. Technology provides a platform for teachers to teach science concepts so that learners are interested in and understand salient parts of the topic/content. Pedagogy covers the methodology, how and when the covered and taught content became fruitful for the learner. Therefore, teaching strategies must follow new pedagogical techniques to achieve goals. Content knowledge supports the tutor in learning and comprehending a better outcome for presenting in classrooms. TPACK is a powerful concept to fulfil the needs of learners and society. Nowadays, technology and education are measured together, and in education, technology has become a requirement (Dumpit & Fernandez, 2017). According to (Edelson, 2001; Jimoyiannis 2010), in classroom learning and teaching, technologies have thoughtful and permanent impacts as being an influential cognitive tool for teachers and students to use advanced skills to solve problems. Computer technology uses software and applications for teaching science education, animation, simulation, modelling, intelligent tutoring, and scientific databases to sort out a variety of affordances for teachers and students. According to Wang (2020), teachers' partial knowledge and services, lack of resources, and incomplete support caused the technology integration blockade. Teachers must learn new models to engage students and develop innovative ideas for changing the world.

2 Literature Review

The TPACK Model, designed by Kohler & Mishra (2006), helps teachers in teaching subjects with technology. Science is crucial in secondary school, and teachers must embrace technology to assist young people. Numerous academics have created new technology integration models as technologies have been steadily included in the teaching and learning process. TPACK framework established by Koehler and Mishra, called technological pedagogical content knowledge, gained popularity in 2006. According to (Chieng & Tan, 2021), 15.9% of Science subjects were identified as one of the essential fields revealed in various TPACK investigations.

2.1 TPACK Model

The TPACK Model was introduced in the 21st Century's first decade, and the concept of TPACK still wanted to explore. Similarly defined by Soomro S et al. (2018), the first generation of TPACK from 2006-16, called the first decades, in the first decade of TPACK constructs described and interpreted by researchers. It has arrived in its second decade, but the silent background characteristic must still be detailed. The TPACK framework initiates without technology by Shulman's (1986 & 1987) Pedagogical Content Knowledge (PCK) to designate how teachers' thoughtful enlightening skills interrelate with technology to create operational teaching. The TPACK model shows how a better comprehension of teacher education technology and PCK influences efficient technical education and is based on a description of PCK (Mishra & Koehler, 2008). Although different notational schemes are frequently employed, numerous other scholars and publications have examined similar concepts (Graham, 2011).

According to this paradigm (see Figure 1), instructors' areas of competence can be broken down into three primary constructs & four are links from three core constructs: content, pedagogy, and technology. The links between these forms of knowledge—referred to as TPACK, PCK "Pedagogical Content Knowledge", TCK "Technological Content Knowledge", TPK "Technological Pedagogical Knowledge", and TPK "Technological Pedagogical Knowledge" are essential to the paradigm, TPCK "Technological Pedagogical and Content Knowledge" are equally significant in this model, the TPACK model developed by (Koehler & Mishra, 2006), explore knowledge about teachers' the result was the arrangement of these seven knowledge constructs.

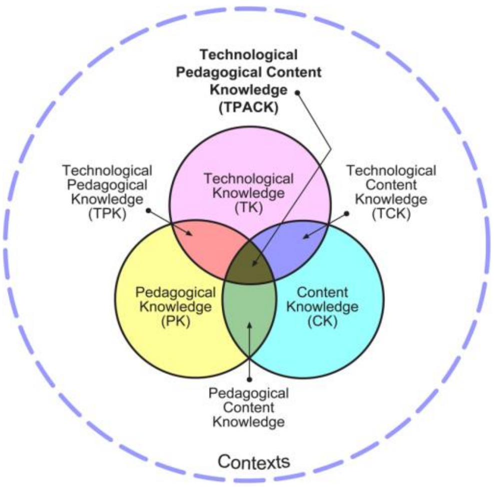

Figure 2.1: TPACK Model

2.1.1 Technological Knowledge (TK)

This knowledge includes more sophisticated technologies like the internet, digital videos and fundamental technologies, corresponding books, chalk, and a chalkboard. The abilities necessary to use specific technologies are included in technological knowledge, which is knowledge about analogue to digital technologies (Mishra & Koehler, 2006). The first construct, Technological Knowledge, has continuously been a favorite when associated with the other two fundamental components of the TPACK Model (Karatas et al., 2016). As a result, it takes time to decide. Every definition of technical knowledge may need to be updated when publishing (Keengwe & Georgina, 2012).

2.1.2 Pedagogical Knowledge (PK)

Knowledge of instructional methodologies and philosophies, classroom organization, and administration are all included in pedagogical knowledge (Shulman, 1987). Knowledge of the teaching and learning process and procedures is devoted to "pedagogy", comprising objectives, principles, and other elements of education (Koehler & Mishra, 2008). This construct places a focus on the personalities of the teachers. It deals with knowledge of a wide range of instructional procedures, tactics, plans, and strategies to facilitate students' learning in the classroom (Koehler et al., 2014). A secret and attainable understanding of a screening cycle, practice, or tutoring method is known as pedagogical knowledge (PK).

2.1.3 Content Knowledge (CK)

Content Knowledge (CK) refers to information about almost the fundamental subjects pupils will be taught in school (Koehler & Mishra, 2008). The information required of students at a given institution of higher learning (Shulman, 1987). Similarly explained by Shulman in 1986, the quantity of actual knowledge and organization in a teacher's head is referred to as content knowledge (CK). It is the breadth and depth of knowledge in a subject (Miller, 2009). This concept applies to any subject requiring teachers to use their expertise in all the areas they were required to teach in school (Koehler et al., 2014). Content knowledge (CK) is the tutor's understanding of the subjects he tries to become qualified in and teach. According to Sahin (2011), the topic matter may vary depending on the level of education, just as high school subject matter may change from that of a university or other levels.

2.1.4 Technological Pedagogical Knowledge (TPK)

Understanding how technology and content interact and impact one more is mentioned as technological pedagogical knowledge (Koehler & Mishra, 2008). This expertise accepts how to modify coaching and learn by using particular technologies in particular ways (Harris, 2009). Technology pedagogical knowledge (TPK) is using pedagogical techniques appropriate for technological instruments and understanding how specific technologies may alter instruction (Mishra & Koehler, 2006). Technological Pedagogical Knowledge (TPK) denotes how technology is perceived as either being beneficial or, in another way, hindering a particular educational approach to teaching (Koehler et al., 2014). TPK is the learning of how precise technologies utilized in precise ways can modify teaching and learning. Therefore, TPK demands a future-focused, creative, and open-minded methodology to use technology, not for its own sake but to advance student learning and comprehension.

2.1.5 Pedagogical Content Knowledge (PCK)

It mixes pedagogy knowledge and content knowledge relevant to the instruction of a particular subject (Shulman, 1987; Koehler & Mishra, 2008).

This information comprises the past knowledge of the pupils, various pedagogical tools, effective teaching techniques, and teaching tactics specific to a given topic (Mishra & Koehler, 2009). In order to guarantee that students in a particular framework well understand the content; as a result, the way the teaching has been structured, scheduled, examined and offered, how and what is taught, and it is created for tenaciously using pedagogical content knowledge (PCK), which is the combination of both rich terms of knowledge "pedagogy and content" (Loughran et al., 2012). Knowledge of content relevant to an individual subject's instruction is known as pedagogical content knowledge (PCK) (Koehler & Mishra, 2008).

2.1.6 Technological Content Knowledge (TCK)

This section focuses on comprehending how technology and content interact. In most cases, technology and its roles in education services define and limit discipline knowledge (Koehler et al., 2014). Technological Content Knowledge (TCK) is the understanding of numerous technologies and how to employ them in the classroom depending on the subject matter and to alter how students comprehend topics (Padmavathi, 2017). This knowledge is an awareness of how content and technology interact and influence one another (Koehler & Mishra, 2008). It alludes to understanding how technology might produce fresh representations of particular information (Thompson, 2011). Technology and subject-matter experts have a long history together.

2.1.7 Technological Pedagogical Content Knowledge (TPCK)

This section provides information on the intricate connections among technology, pedagogy, and content that teachers can use to progress effective and subject teaching strategies in the classroom (Koehler et al., 2014). A developing knowledge frame known as TPACK drives beyond the three "core" fundamentals "Content, Pedagogy, and Technology". An understanding that outcomes from interactions among content, pedagogical, and technological knowledge are known as "Technological Pedagogical and Content Knowledge". TPACK is distinctive from the individual indulgence of any of the three philosophies, underpinning extremely relevant and skilful teaching with technology. Expert tutors use TPACK whenever they teach by merging their knowledge of technology, pedagogy, and material simultaneously. There is no one technical solution that works for all teachers, all courses, or all points of view on teaching because each circumstance offered to teachers is a unique combination of these three elements.

3 Methodology

3.1 Materials and Methods

This study is quantitative method and descriptive design with a survey technique were selected by the researchers, to investigate Secondary science teachers' TPACK profiles and evaluate TPACK competencies regarding gender, experience level, and age.

3.2 Population & Sampling

The primary focus of this study was on secondary science teachers from secondary schools. Only science degree teachers from secondary education in the Mirpurkhas division were chosen for the participant pool. A total of 300 participants worked in Secondary schools of Mirpurkhas Division. The total of 172 participated completed the online survey.

3.3 Instrumentation

To measure the profile of Science Teachers, the popular instrument known as The Technological Pedagogical and Content Knowledge (TPACK) was developed by Punya Mishra and Matthew J. Koehler of Michigan State University in 2006. The TPACK instrument consists of seven constructs; there were 26 Likert – type items or statements: 4 items of TK, 6 items of PK, 3 items of CK, 4 TPK, 2 items of PCK, 3 items of TCK, as well as 4 items of TPCK. It has been extensively tested and applied in various studies in the field of science education research around the world.

3.4 Data Collection

The Google doc survey method was used to collect data from participants, and the link was shared in email and WhatsApp groups with the help of secondary school teachers.

3.5 Data Analysis

To determine the teachers' degree of TPACK, the researcher first calculated the data using a descriptive study, measuring their frequency, percentage, mean, and standard deviation. This descriptive survey research aimed to explore TPACK profile science teachers to self-assess their technological, pedagogical, and content knowledge (TPACK). To find the difference in gender, age & experience of the participants; the researcher used Chi-square test to evaluate the differences among moderating variables.

4 Results & Discussion

4.1 Data Analysis & Interpretations

A. Descriptive Analysis

4.1.1 Gender Wise Representation of Respondents

Sr.no	Gender	Frequency	Percentage
1	Male	127	73.8%
2	Female	45	26.2%

Table 4.1 Research participants' gender wise frequency were (Male=127 & Female=45).

4.1.2 Experience wise Representation of Respondents

Sr.no	Experience	Frequency	Percentage
1	0-5	80	46.5%
2	6-10	61	35.5%
3	11-15	12	7.0%
4	16+	19	11.0%

Table 4.2 Research participants' experience wise frequency were (0-5=80; 6-10=61; 11-15=12; & 16+=19).

4.1.3 Age wise Representation of Respondents

Sr.no	Age	Frequency	Percentage
1	26-35	81	47.1%
2	36-45	58	35.7%
3	46+	33	19.2%

Table 4.3 Research participants' age wise frequency were (26-35=81; 36-45=58 & 46+=33).

4.1.4 Item wise Analysis

Items	Mean
I have the technical skills to use the internet and computers effectively	2.28
I learn technology easily	2.40
I know how to solve my own technical problems when using technology	2.33
I keep up with popular new technologies	2.51
I am able to stretch my students' thinking by creating challenging tasks for them	2.01
I am able to guide my students to adopt appropriate learning strategies	1.98
I am able to help my students to monitor their own learning	1.98
I am able to help my students to reflect on their learning strategies	1.97
I am able to plan group activities for my students	1.99
I am able to guide my students to discuss effectively during group work	1.98
I have sufficient knowledge of science	2.25
I can think about the content of science like a subject matter expert	2.11
I am able to develop a deeper understanding of the content of science	2.12
I am able to use technology to introduce my students to real-world scenarios	2.40
I am able to facilitate my students to use technology to find more information on their own	2.28
I am able to facilitate my students to use technology to plan and monitor their own learning	2.28
I am able to facilitate my students to collaborate with each other using technology	2.27
Without using technology, I can address the common misconceptions my students have about science	2.07
Without using technology, I can help my students to understand the content knowledge of science in various ways	2.08
I can use the software that is created specifically for science (e.g., data loggers for science	2.25
I know about the technologies that I have to use for research of the content of science	2.26

I can use appropriate technologies (e.g., multimedia resources, simulation) to represent the content of science	2.26

I can teach lessons that appropriately combine science, technologies, and teaching approaches	2.22
I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn	2.16
I can use strategies that combine science, technologies, and teaching approaches that I learned about in my coursework in my classroom	2.25
I can provide leadership in helping others to coordinate the use of science, technologies, and teaching approaches in my school and/or district	2.10

Table 4.4 Research participants' item wise mean score.

Above table present the item mean wise score of the data. The highest mean score is (m=1.97) that mean teachers has full command on the pedagogical knowledge. Whereas lowest mean score is (m=2.40) which shows that the neutral stage of technological knowledge teachers autonomy in the learning technology easily at this stage.

4.1.5 Factor wise Analysis

Constructs of TPACK	N	Mean	SD	A
Technological Knowledge (TK)	172	2.40	3.461	.956
Pedagogical Knowledge (PK)	172	1.97	2.954	.982
Content Knowledge (PK)	172	2.12	1.785	.874
Technological Pedagogical Knowledge (TPK)	172	2.30	3.075	.919
Pedagogical Content Knowledge (PCK)	172	2.06	1.483	.947
Technological Content Knowledge (TCK)	172	2.26	2.154	.963
Technological Pedagogical Content Knowledge (TPCK)	172	2.20	3.495	.965
1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly Disagree				

Table 4.5 Research participants' factor wise mean, standard deviations, and the alpha values.

Above table present the factor wise mean score of the data. The mean score is technological knowledge (M= 2.40), pedagogical knowledge (1.97), content knowledge (M=2.12), technological pedagogical knowledge (M=2.30), pedagogical content knowledge (M=2.06), technological content knowledge (M=2.26), and technological pedagogical content knowledge (M=2.20). These mean scores shows that teachers are not familiar with using technology while teaching. More over the technological knowledge (M=2.40) has low mean score as compare to the others. The pedagogical knowledge (M=1.97) shows that teachers know that teaching strategies they need to teach the students.

B. Inferential Statistics

4.2 Hypothesis Analysis

4.2.1 $H_{1:}$ H_0: There is no significant difference in the TPACK profile of male and female science teachers.

CHI-SQUARE TESTING FOR HYPOTHESES SUMMARISED GENDER DIFFERENCES IN SEVEN TPACK CONSTRUCTS

Constructs	Pearson Chi-Square	Likelihood Ratio	df	p-value
TK	**4.105**	4.176	4	**.392**
PK	**6.186**	8.272	4	**.186**
CK	**7.386**	11,593	4	**.117**
TPK	**7.726**	10.094	4	**.102**
PCK	**7.526**	8.728	4	**.111**
TCK	**17.731**	20.065	4	**.001****
TPCK	**7.794**	8.181	4	**.099**
N of valid cases 172				

The above table (see Table 4.6) illustrates the chi-square test result from the participant responses for all constructs TPCK. Six out of seven constructs have greater than 0.05 p value. There was strong evidence to accept the null hypothesis. There is no significant difference that exists between the gender groups for

TPACK Constructs except TCK. Female teachers slightly perform better than males in TCK construct.

4.2.1 H_2: H_0: There is no significant difference in the TPACK profile of science teachers through teaching experience.

Constructs	Pearson Chi-Square	Likelihood Ratio	df	p-value
TK	24.949	20.704	12	.015
PK	31.336	25.105	12	.002
CK	22.320	18.470	12	.034
TPK	49.063	35.554	12	<.001
PCK	34.045	28.718	12	<.001
TCK	46.968	33.836	12	<.001
TPCK	41.026	29.199	12	<.001
N of valid cases 172				

Table 4.7 displayed the results of all constructs have less than 0.05 p value. There was strong evidence to reject the null hypothesis. There are no significant differences exists between the experience groups for TPACK constructs. This confirms that teachers' experiences affect the performance of TPACK model.

4.2.1 H_3: H_0: There is no significant difference in the TPACK profile of science teachers through age.

Constructs	Pearson Chi-Square	Likelihood Ratio	df	p-value	Results
TK	15.574	12.560	08	.049*	
PK	7.018	9.151	08	.535	
CK	3.701	4.146	08	.883	
TPK	28.163	29.951	08	<.001**	
PCK	12.007	13.714	08	.151	
TCK	14.944	15.566	08	.060	
TPCK	26.181	24.698	08	<.001**	
N of valid cases 172					

Table 4.8 shows that the four out of seven constructs have greater than p value, two constructs have less than <.001 value and TK construct have .049* p value. There was no significant difference observed between the age groups for TPACK constructs except TK, TPK, and TPCK. In TPK found the difference between 26-35 & 36-45 age group, while in TPCK have found difference among groups except 46+ years.

Conclusions

The study's conclusions suggest a thorough and in-depth examination of science instructors' perceptions of technology integration through the use of TPACK and constructs of the TPACK Model "technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical and content knowledge (TPACK)". For further research, connect all authorities like head teachers, class teachers, students and lab technicians. Explore more about TPACK Model with training, workshop, and seminars. Creating an environment for the science teachers Consider TPACK should also be acknowledged. It is advised that teacher education programmes hold comprehensive courses and training to enhance technology integration into science courses for future science instructors.

With the shortage of science labs and apparatus in secondary schools, technology fulfils the gap with ideal experiments through computer technology which is possible to learn TPACK Model.

Recommendations

A number of suggestions can be made to improve technology integration into science education by using the TPACK model as a lens, based on the study's conclusions. Provide thorough training courses and workshops with the goal of improving the technological, pedagogical, and content knowledge (TPACK) of science teachers. Include a range of stakeholders in the training and workshop sessions, such as lab technicians, students, head teachers, and class teachers. The effective integration of technology in science education depends on the participation of all stakeholders, whose opinions and suggestions should be respected. Incorporate interactive workshops and seminars into the training courses so that teachers can try out various technology and teaching methods in a safe setting. Give science teachers continual assistance and opportunities for mentorship as they integrate technology-enhanced lessons into their classrooms. Peer mentoring, online tools, and technical support to solve problems and exchange best practices are just a few instances of this support system. Create a welcoming environment in the classroom where experimenting and creativity in instruction are valued. Promote cooperation among scientific instructors and highlight and honor effective instances of integrating technology into science education. By putting these suggestions into practice, educational institutions can foster an atmosphere that enables science teachers to successfully use technology into their lesson plans, thus improving the learning outcomes for science education students.

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