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Development of TPACK for Teacher-Educators: A Technological Pedagogical Content Knowledge Scale

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***Abstract*---**The purpose of this study is to develop a valid and reliable TPACK (technological pedagogical content knowledge) scale based on the core components of TPACK framework in order to measure teacher-educators' TPACK. For this purpose, 46 statements were developed and tested by 5-point Likert type scale. Data were collected from 642 teacher educators working in different colleges of education under different universities in state of Punjab. The collected data was analyzed by using SPSS 22.0 software. The Exploratory Factor Analysis (EFA) was carried out in order to investigate the factor structure of the scale. EFA resulted in six factors named as Pedagogical skills, Creative thinking skills, Ethics, Instructional design, Innovativeness and Virtual learning environment. The Cronbach's Alpha coefficient for the whole scale was calculated as .848. The KMO value was calculated as .889 and the Bartlett's Test of Sphericity examined (chi-square = 17196.73; df = 1035), which is significant (P-Value<.001). Based on result and in comparison with the Cronbach's alpha coefficient values for other TPACK surveys in the literature as a whole and for their sub-components the TPACK scale established here can be said to have a high level of reliability in terms of its factors and as a whole.

***Keywords*---**development TPACK, teacher-educators, teacher-training colleges, technological pedagogical, TPACK.

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Introduction

In today's educational practices, the effective usage of technology in education becomes potential only when teachers, who are accountable for teaching, guiding and directing students, are trained or well-equipped in a way that will enable them to use instructional technologies effectively (Önal & Çakır, 2015). The dearth of educators' know-how, abilities, skills and proficiencies with related to the usage of technology in teaching process have been acknowledged as the foremost obstacles to technology integration (Bingimlas, 2009; Brinkerhoff, 2006; Chen et al., 2009; Lim & Khine, 2006; Hew & Brush, 2007; Oncu et al., 2008; Özdemir & Kılıç, 2007; Shulman, 1986; Yalin et al., 2007). In order to ensure that educational practices should not deviate from its normal path teachers have to become techno-pedagogue. Transformation of teachers to techno-pedagogue would not only increase the capability of the teachers but also make the teaching-learning process effective and efficient and they will bring the entire world into the class-room as well as to make students competitive in the international arena. One of the techno-pedagogical integration approaches in the field of technology integration in educational practices is the framework of Technological Pedagogical Content Knowledge (TPACK or TPCK) (Kramarski & Michalsky, 2010; Smyrnova et al., 2021; Lukiianchuk A et al., 2021).

In TPACK knowledge, there are three areas of knowledge, namely: content, pedagogy, and technology. Content is the subject matter that is to be taught. Technology comprises present technologies such as computer, Internet, digital video and commonplace technologies including overhead projectors, blackboards, and books. Pedagogy describes the collected practices, processes, strategies, procedures, approaches and methods of teaching and learning. It also comprises knowledge about the aims of instruction, assessment, and student learning. (Archambault & Crippen, 2009; Cox & Graham, 2009). Lee & Tsai (2010), found that meaningful use of ICT in the classroom requires the teachers to integrate technological affordances with pedagogical approaches for the specific subject matter to be taught. Essentially, research evidence shows that in spite of the many efforts that researchers and educators invested over the years in preparing teachers to use technology in educational setup ,but teachers still lack the skills and knowledge needed to be able to teach with technology successfully (Koehler et al., 2007; Rodrigues, 2003). Voogt (2013), and Tokmak et al. (2013), note that there are several studies showing that education institutions have problems integrating technology into education because the unskillfulness of teacher-educators for using technology during teaching learning process.

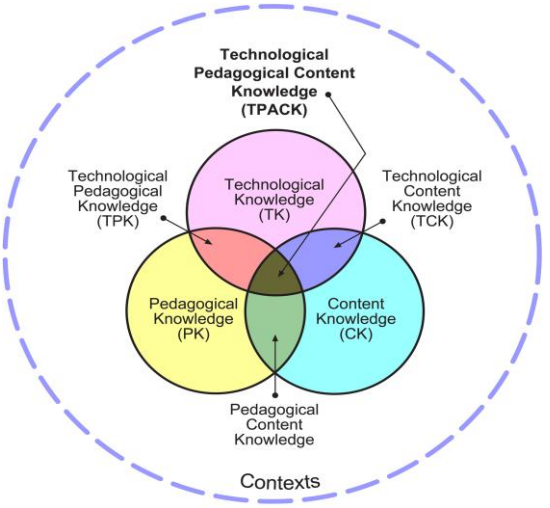

Figure 1. The TPACK framework and its components

Figure 1 represents the TPACK framework and its components. There are seven components of TPACK models are, "Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPCK) or TPACK." (i) "TK" refers in what way to use computer software and hardware presentation gadgets & other technologies used in educational contexts. (ii) "CK" mentions to the teacher's know-how related to the content matter to be imparted into the class room. (iii) "PK" mentions to the set of skills teachers must develop and teacher's deeper know-how related to the procedures and methods/techniques of teaching & learning. (iv) "PCK" denotes to the know-how of the subject/topic, mind-set of the learner, psychology of learning etc. are the important factors that determine the appropriate selection of the methods/techniques for teaching. For example: art, drama, puppetry, role play, nature rambling, field trips, laboratory method, project method etc. (v) "TCK" mentions the way in which technology and content influences each other (Larner & Timberlake, 1995; Lawless & Pellegrino, 2007; Loucks-Horsley et al., 1998). Teacher should be familiar of the innovative technologies available in the global market for the effective transaction of the subject matter. For example: Virtual Labs, Virtual field trips, e-library, educational softwares etc. (vi) "TPK" denotes to the reciprocal relationship between technology and pedagogy like how teaching and learning can alter when scientific know-how or technologies are used in specific ways. This comprises knowing technological tools for appropriate pedagogical designs and strategies. (vii) "TPACK" as a synthesised resource of "Technological knowledge (TK), Content knowledge (CK), Pedagogical knowledge (PK), Pedagogical content knowledge (PCK), Technological content knowledge (TCK), Technological pedagogical knowledge (TPK)", with a target upon how technology can be exclusively knitted to encounter pedagogical necessities to impart certain content in particular settings so as to assure worthwhile learning (Koster et al., 2005; Cochran-Smith, 2005; Erdogan & Sahin, 2010; Hepsiba et al., 2017).

TPACK competency is the art of integrating sound pedagogic principles of teaching/learning with the use of technology. It refers to weaving the techniques of the craft of teaching into the learning environment itself. Acquiring TPACK proficiencies make teaching and learning a pleasurable exercise as it would lessen the pressure on the teachers and enable the students to delve deeper into domain of knowledge. Techno-pedagogical competencies are the ways to make accessible and affordable quality education to all. The NCF (2005), and XII five year plan (2011), emphasized to provide connectivity, valuable content and low cost computing devices to all the Institutions of higher learning in the country. This hybrid skill facilitates to enhance linguistic abilities, to sketch specific pedagogy with advance study materials, to design multi-grade instruction (Kessler, 2006; Kimmel et al., 1999; Kipsoi et al., 2012; Sribagus et al., 2017).

Today, TPACK expertise is very much needed for teacher-educators because they facilitate the prospective teachers and make them to become techno-pedagogues. Hence teacher-educators need to provide opportunities to get practical knowledge, pedagogical – skills by using the current technology during their teaching-learning process, YURDAKUL (2011). Techno-Pedagogical expertise needs to be improved in order to equip teacher educators to face the students belong to the digital era and also to face the challenges in the modern classroom, Sathiyaraj & Rajasekar (2013).

Present-day, the TPACK skill is very much needed for teacher-educators, as it eases effective teaching and learning and assists prospective teachers to use efficiently Lee & Tsai (2010). Because teachers are the greatest assets of any education system. They stand in the interface of the transmission of knowledge, skills and values. They are accepted as the backbone of whole education system. Teacher quality is therefore crucial and has been globally accepted to be significantly associated with the quality of education in general and students' learning outcomes in particular. The Education Commission (1964-66) of India accepted this influence of teachers in powerful words, "No system can rise above the status of its teacher". Experiences of various countries reveal that the most effective way to develop good teachers in a dynamic and changing environment is to begin with a well developed in-service teacher education programme. Each society, therefore, makes some provision for in-service education and continuous professional development of in-service teachers in order to help them to contribute in the growth of society (Goldhaber & Brewer, 2000).

As stated by Yurdakul et al. (2012), it should not be forgotten that providing classes with technological materials does not mean that it will increase the quality of the teaching and learning process. Stating that the type of individuals forming society is directly associated with the type of teachers in education, and that the importance of teachers for the education of individuals in society cannot be ignored, Voogt (2013), also argues that if the aim is to raise individuals for information society, teachers should be provided with an education that enables them to be role models for an information society. Better teaching was not done merely introducing Technology or ICT as a compulsory subject in schools and teacher education curriculum. In fact meaningful use of ICT in the classroom demands the teachers to integrate technological affordance with pedagogical

TPACK approaches for the specific subject matter to be taught Koehler & Mishra (2005).

Hence "TPACK" is one of the techno-integrated pedagogical and content knowledge, framework emphasis on efficient use of technology used in pedagogical and content knowledge in educational process. Generally, TPACK framework is one of the technology integration models that focus on effective technology integration in the teaching process with respect to teacher competencies. TPACK structure stresses not only on techno-integration with respect to the teacher-educators' know-how about scientific know-how or technology usage but also with relation to the communication and amalgamation of teacher-educators' know-how in the area of scientific know-how or technology, pedagogy and content (Bernier & McClelland, 1989; Blanchard, 2010; Borko, 2004; Lefebure, 2019).

Review of related literature

Teacher-educators are the effective and dominating factors among the ones contributing to educational improvements. They are required to have TPACK (Technological pedagogical content knowledge) knowledge proficiencies to make teaching-learning process effective (Kalogiannakis, 2010). Technologies have played a dominating part in the whole education process. Researchers have exposed TPACK competencies support higher-level know-how and rational skills among educators.

TPACK skills are the ways to make accessible and affordable quality education to all. (Tsou et al., 2006), Technologies have played a dominating role in the whole education process. Researchers have shown TPACK competencies support higher-level learning and thinking skills among students. It's proved to have positive effects in language learning and it becomes as an integral part of education and contributed as teaching tools in the language classroom. There is a great deal of interest to learn more about the potential use of ICT in education practices. Pelgrum (2001), identified several reasons why technologies have become important to education process because of reducing the costs of education, supporting the computer industry, preparing students for work effectively and living in a technology savvy world.

Technological Pedagogical Content Knowledge is referred to as TPACK today. However, it was used as TPCK in earlier writings in the research. TPACK is a teacher knowledge structure evolved by including technology knowledge into the teacher knowledge structure that Shulman (1986), basically determined as "pedagogical content knowledge". This framework was designed as a outcome of a five-year research program emphasized on teacher professional development and faculty development, and was carried out by using design based experimental research method (Koehler & Mishra, 2005; Mishra & Koehler, 2006). TPACK is an approach established from Pedagogical Content Knowledge (PCK) put frontward by Shulman (1986). Shulman (1986), specified that the notions of Pedagogy, Content and Knowledge should be considered as independent of each other in the teacher education process and acquired interactively. TPACK is a philosophical tactic that takes PCK as a basis in technology assimilation. Observing the notion

of PCK, Koehler & Mishra (2009), specified that technology should be taken into consideration collected with PCK and put frontward the concept of Technological Pedagogical Content Knowledge (TPCK, TPACK). TPACK has been taken into attention in the current study since it constitutes the basis of a number of latest studies as a model of technology integration into education (Cox & Graham, 2009; Niess et al., 2009; Sahin, 2011). Technological Pedagogical Content Knowledge (TPACK) is fundamentally defined as a structure of teacher knowledge for technology incorporation. Teacher knowledge is defined as a complex interaction and intersection among three bodies of knowledge within the framework of TPACK: content, pedagogy and technology (Koehler & Mishra, 2005; Mishra & Koehler, 2006).

Yurdakul et al. (2012), revealed in his study that pre service teachers need to provide opportunities to get practical knowledge and skills to use current technology during their teaching learning process. For that courses TPACK knowledge need to be added in teacher training programs. The technology centers in teaching and learning must be established in higher education institution.They developed TPACK scale in order to assess the 995 Turkish pre service teachers' TPACK (Technological pedagogical content knowledge). The sample was split into two subsamples on random basis and found that the TPACK-deep scale was a valid and reliable instrument for measuring TPACK. Techno-pedagogical competency is the art of integrating sound pedagogic principles of teaching/learning with the use of technology (Hoyle, 2018; Hurt et al., 1977; Kárpáti et al., 2008; Nias, 2002).

Almada et al. (2014), exposed in their study that the integration of ICTs in the classroom depends on the teachers' ability to scaffold the learning environment by using effective Technology-based pedagogies. TPACK capability is much required for teacher-educators as it facilitates effective teaching and learning along with assists prospective teachers to usage it efficiently, Lee & Tsai (2010). Over the past 25 years, there have been many studies in local, national and international scopes to integrate TPACK competencies in whole education process. These studies aim to improve the effects of teacher training through technology (Cavas, 2010), levels of resources, teachers' pedagogies and practices (Watson, 1998), and the effects of computers and technology on students' achievement (Cavas, 2010). Meanwhile, a number of studies show that the successful implementation of techno-pedagogical competences in teaching learning process make educational practices more productive and efficient and provide a better learning engagement experiences (Leask & Pachler, 1999). When used appropriately, techno-pedagogical competences have high potential to enhance teaching and learning, and will provide good opportunities for pre service teachers to improve their techno-pedagogical competences (Haddad & Draxler, 2002).

The conquest of any educational practices rests on the understanding and familiarity of teacher-educators towards the efficient usage of techno-integration pedagogical and content knowledge (TPACK) competencies in whole education process. Understanding the knowledge and levels of teacher-educators towards TPACK matters a lot and is very essential (Hackett et al., 2001; Harvey, 1999; Howell, 1996; Mingaine, 2013). Also vital is to know the levels of technological tools or devices used in teaching learning process to make efficient prospective

teachers (Huang & Liaw, 2005). Teacher-educators are the effective and dominating factors among the ones contributing to educational improvements. The know-how of TPACK is an ideal for educators to achieve. It refers to something that the educator possesses, such as concepts, rules, strategies, methods, teaching-styles and technology. Many researches accomplished to identify pre-service or in-service educators' TPACK. It is crucial to determine the impact of interferences, interactions as well as professional growth programs to identify the current state of educators 'knowledge (Koehler, & Mishra, 2009).

Many investigators continue to fault educators for the dearth of technology assimilation in schools and colleges though investigators do not blame them deprived of seeing the perspective for teaching, educators' perceptions about teaching and learning, know-how of pedagogical skills and professional growth (Sandholtz et al., 1997). Some researches exposed that efficient assimilation is precisely linked with pedagogical know-how of educators as well as their know-how of content knowledge in educational institutions (Vrasidas & McIsaac, 2001; White et al., 2002; Hosseini & Kamal, 2012). In other words, the efficient assimilation procedure is intently associated with know-how of techno-integrated pedagogical skills (Hew & Brush, 2007). However the success of any educational institutions depends on the understanding and familiarity of educators' know-how towards the pedagogical decisions. As well as many frameworks of educators' knowledge have stressed that educators must have sound understanding in their pedagogical decisions (Pitts Bannister & Mariano, 2013). Understanding the know-how and skills of teacher-educators towards TPACK is very vital and it is one of such framework which has accepted consideration of investigators (Mishra & Koehler, 2006). TPACK framework has become a core part in educational process and contributes as teaching tools in the language class room also. Under this structure, content, pedagogy and technology cannot be considered as separate bodies of knowledge.

Basically, research testimony shows that investigators and educators spent many years on research in making teachers to use techno-integration classes in order to better outcomes but in spite of that teachers still absence of skills as well as desirable knowledge to be competent to impart techno-integrated teaching and learning successfully (Koehler et al., 2007; Rodrigues, 2003). Voogt (2013), and Tokmak et al. (2013), noted that due to incompetent teachers into education process, they are facing snags to assimilate technology into teaching learning process. Similarly, Yurdakul et al. (2012), also declared that the inefficiencies of teachers in terms of know-how of various teaching skills as well as incompetency in technology are the foremost hindrances to assimilate techno-integrated teaching and learning in class room. As stated by (Hew & Brush, 2007), the technology assimilation obstacles comprise not only the absence of particular technology and teaching skills but also the absence of technological backed pedagogical and content knowledge.

A common review of research regarding TPACK discloses that, although there are researches accomplished to assess each part of TPACK, the number of studies concentrated on defining the connections between these sections is inadequate (Archambault & Crippen, 2009). It was observed in studies on the enlargement of TPACK-linked studies that each one of the parts TPACK framework was studied

individually. Further, there are restricted studies accomplished to assess the TPACK component that explains their connections and amalgamation of each component dealing within the TPACK model, which is there are no data collection tools such as scales, surveys, interviews, checklists or questionnaires related to the measurement of the TPACK component. It was also identified in the study that further research is needed with the emphasizing that the TPACK framework should be impeccably clear and understandable (Archambault & Crippen, 2009; Cox & Graham, 2009). Therefore, the purpose of this study is to develop a TPACK (Technological Pedagogical Content Knowledge) scale based on the core components of TPACK framework. In other words, the purpose of present research is to develop a valid and reliable TPACK scale based on the TPACK components found within the TPACK framework in order to measure teacher educators' TPACK (Technological pedagogical content knowledge) (Gerard et al., 2010; Gerard et al., 2011; Guskey, 1986; Graham, 2011).

Research Method

The objective of this study is to develop a Scale for measuring TPACK based on the main components of TPACK structure by means of a systematic and step-by-step approach as follows:

Phase I: Item pool phase

As per the recommendation of Churchill (1979), and Hinkin (1995), researchers used deductive approach to generate statements for the scale development as well as followed an extensive and thoroughly review of literature dealing with the proposed factor i.e. TPACK Competencies. Initially researcher framed 62 statements from the extensive review of literature measuring TPACK competencies among teacher-educators which comes under six competency areas of TPACK (Instructional Design, Innovativeness, Ethical Awareness, Creative Thinking skill, Virtual Learning Environment and Pedagogical Skills). These competencies areas are technology integration standards for teacher-educators conducting the teaching and learning process based on TPACK. The purpose in developing these standards is to define and determine a teacher-educator's knowledge, skills and attitudes of TPACK according to the views of the field experts.

A total of 62 items were written down in the item pool. Following this step, the statements were simplified and combined with the items which overlapped with each other. As a result of this initial step, the number of items from the item pool was shortened to 59. Finally the scale form was prepared by using items from the item pool. Researcher used Thurstone, Likert type scaling technique mostly used in survey questionnaire research, and are the most useful in behavioral research. They also are most suitable for use in factor analysis (Desjardins & Peters, 2007; Elliott, 1992; Ericsson & Lehmann, 1996). Thence researcher used a five point Likert type scale for measuring Techno-Pedagogical (TPACK) competencies of teacher-educators with 5 as "Strongly Agree" and 1 as "Strongly Disagree".

In order to determine the face and content validity of the scale form prepared, the experts were asked for their views prior to the execution process. For this purpose, the TPACK competency scale was presented to a total of 12 experts

(Professors, Chairpersons and Head of Departments) and they reviewed the initial pool of items on three categories, i.e. "not representative", "somewhat representative" or "clearly representative" as per the suggestions of Lin & Hsieh (2011). In the initial screening, panel suggested to remove the five items from the scale due to their resemblances in their contents, whereas a new item was included in the scale as suggested by the experts. Subsequently, the number of items in the pool was amended as 54. The scale was revised and further sent to experts. The scale was again assessed on numerous times by the experts, and 1 more item eliminated. The final pool of 53 items was once more reread by the experts and this time no item was removed. Thus, the number of statements in the pool was modified as 53.

Phase II: Scale refinement

The first step in the refinement of the scale is pilot testing. In order to conduct the pilot testing, the questionnaire of 53 statements measuring teacher-educators' TPACK was evaluated on a five point Likert scale (where 1- highly disagree and 5 – highly agree). Researchers used simple random sampling technique and collected a sample of 652 respondents working in different colleges of education under different universities in the State of Punjab for the pilot testing of the scale, which is line up with some other studies, like sample sizes of other scale development studies Parsuraman et al. (1994), and Webster (2003). Out of 652 samples, 10 were removed due to not filling appropriately. In last researcher got 642 responses. The sample constitutes 60% males and 40% females. There was an equivalent representation of faculties from three major streams like arts & humanities, science & engineering and commerce and management. Among 642 teacher educators, (30%) of teacher educators hold doctorate degrees and the rest (70%) of sample constitute employees without doctorate. After that as per the suggestion of Churchill (1979), researchers conducted: (i) Item analysis, and (ii) Exploratory factor analysis in order to explore the factor-structure of TPACK scale.

- Item Analysis: The first step in the scale purification stage as per the suggestions of the Churchill (1979), is the computation of the Cronbach's alpha. Cronbach's alpha measures the internal consistency of the statements that is, how closely related a set of items are as a group. Researchers consider it as a measure of scale reliability. Researchers used SPSS 22.0 to calculate Cronbach's alpha. According to Peterson (1995), the minimum value for Cronbach's alpha is .70. In order to improve the Cronbach's alpha, researchers examined the item to item correlations and items possessing low correlations were removed. This iterative process was repeated numerous times which resulted in the removal of 1 statement from the scale. The improved value of Cronbach's alpha was calculated .848.
- Exploratory Factor Analysis: The next subsequent step for item reduction and purification of the scale is to apply exploratory factor analysis on the remaining 52 items. Researchers applied factor analysis using SPSS 22.0. The Principal component analysis was applied as an exploratory factor analysis factor extraction technique. In order to reset the correlations between factors and to help interpret the factors, Varimax vertical axis rotation was used. The number of factors, the lower limit of the item

eigenvalue was taken as 1.00 to determine the number of factors. Moreover, the factor load lower limit of each item was taken as .40 (Netemeyer et al., 2003), and the lower limit of the differences of each item within the factors was taken as .10 (Coombs & Schroeder, 1988; R.B. Kline, 2005; Tabachnick & Fidell, 1996).

It was attempted to find out whether the data matrix obtained from the sample is appropriate for factor analysis and for factor extraction for exploratory factor analysis. The size of the sample, the Kaiser-Meyer-Olkin (KMO) value and Bartlett's Test of Sphericity (BTS) were taken into account for that purpose. In literature, it is reported that factor analysis necessitates at least 300 people. Based on this declaration, the TPACK scale form was applied to participating 642 teacher-educators (Darling-Hammond, 2001; Day & Gu, 2009; Day et al., 2009; Moor et al., 2005). Following the application, the KMO sample competency was measured in order to test the validity of the size of the sample statistically. The KMO value, which can have a value between 0 and 1, is interpreted as normal if it is between .5 and .7, as good if it is between .7 and .8, as very good if it is between .8 and.9 and as excellent if it is higher than .9. As a outcome of that process, the KMO value was calculated as .889. Since the calculated KMO value was higher than .8, it was considered that the size of the sample was highly acceptable because KMO value is higher than the minimum requirement of 0.6. In addition, the sample size and the correlation matrix is said to be good and to be appropriate for factor analysis if the result of Bartlett's Test of Sphericity is significant. In the present study, when the results of Bartlett's Test of Sphericity test was examined (chi-square = 17196.73; df = 1035; p<.001), as shown in table 3. It is seen that the data are appropriate for the factor analysis.

Table 1
KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.889
Bartlett's Test of Sphericity	Approx. Chi-Square	17196.73
	df	1035
	Sig.	.000

Numerous iterative layers of factors analysis were applied to the data set and removed some items with the aim of improving the factor structure. This resulted in the removal of 6 items as their factor loading and communality value was less than .4 and also left those items which were less than three under factor (Kaiser 1960). Henceforth the results of the factor analysis exposed that TPACK competencies decomposed into six factors which have an Eigen value of greater than one and factor load values ranged between .535 and .913, as shown in Rotated Component Matrix under table 2.

Table 2
Rotated component matrix

Items	Pedagogical Skills	Creative Thinking Skills	Ethics	Instructional Design	Innovativeness	Virtual Learning Environment

TPACK 45	.913					
TPACK 52	.895					
TPACK 48	.882					
TPACK 47	.858					
TPACK 41	.840					
TPACK 43	.739					
TPACK 26		.864				
TPACK 25		.848				
TPACK 28		.822				
TPACK 31		.821				
TPACK 32		.891				
TPACK 19			.644			
TPACK 18			.623			
TPACK 16			.604			
TPACK 17			.578			
TPACK 21			.539			
TPACK 22			.535			
TPACK 4				.889		
TPACK 7				.886		
TPACK 6				.855		
TPACK 12					.862	
TPACK14					.854	
TPACK 11					.815	
TPACK 35						.822
TPACK 34						.820
TPACK 39						.609

As indicated in Rotated component matrix that items 45, 52, 48, 47, 41 and 43 load to the 1st factor. As mentioned earlier, these items were investigating the teacher educators' TPACK competency in teaching-skills hence the 1st factor was named as "Pedagogical skills". Items 26,25,28,31 and 32 load to 2nd factor. Since these items were examining the teacher educators' TPACK proficiency in higher order of thinking, creative thinking, and critical thinking skills hence 2nd factor was named as "Creative thinking skills". Items 19,18,16,17,21 and 22 load to 3rd factor. Since these items were inspecting the teacher educators' TPACK skills in ethical issues in terms of technology usage thence 3rd factor was named as "Ethics". Items 4, 7 and 6 load to 4th factor. In view of these items were exploring teacher educators' TPACK abilities in designing instructions thus 4th factor was named as " Instructional design". Items 12,14, and 11 load to 5th factor. As these items were identifying teacher educators' TPACK capabilities in Innova-tiveness hence 5th factor was named as "Innovativeness". Finally, items 35, 34 and 39 load to 6th factor. As these items were identifying teacher educators' TPACK competencies in online learning environment thus 6th factor was named as "Virtual learning environment" (Creswell & Clark, 2017; Cuban, 1993; Archambault & Barnett, 2010).

After identifying the factors, Cronbach's Alpha coefficients of internal consistency were calculated in order to check the reliability of the subscales and the whole scale. The Cronbach's Alpha coefficients for the 1st, 2nd , 3rd, 4th , 5th and 6th factors of TPACK scale were calculated as .92, .87, .86, .91, .88, and .82 respectively and the Cronbach's Alpha coefficient for the whole scale was calculated as .84. While the reliability of the 1st and 4th factors as well as whole

scale were considered as 'excellent' and the reliability of 2nd, 3rd , 5th and 6th factors were considered as 'very good' (Kline, 2005).

Discussion

Present-day, the TPACK skill is very much required for teacher-educators, as it eases effective teaching and learning and assists prospective teachers to use efficiently Lee & Tsai (2010). TPACK framework, in terms of both theoretical and practical facets, has a generally recognized formation for efficient technology combination. Still, the necessity to comprehend, simplify and enlarge the TPACK framework has been highlighted in linked studies (Archambault & Crippen, 2009; Cox & Graham, 2009; Jimoyiannis, 2010). Moreover, utmost of the studies linked to the evaluate of TPACK are emphasized on isolated TPACK components. It has been that TPACK components are at the core of TPCK framework (Koehler & Mishra, 2009; Koehler et al., 2007). The present study was deliberate and carried out depending on the lack of similar research in the related literature.The purpose of this study was to propose a TPACK scale based on the core components of TPACK structure in order to measure teacher-educators' TPACK in the region of Punjab.

A systematic and step-by-step approach was followed for the development of the scale. Based on the literature review, it was predicted that the TPACK competencies among teacher-educators which comes under six competency areas of TPACK (Instructional Design, Innovativeness, Ethical Awareness, Creative Thinking skill, Virtual Learning Environment and Pedagogical Skills). However, the data analysis results revealed, the TPACK scale includes 26 statements and six-factor structure. These factors are named in accordance with the literature as follows: (1) Pedagogical skills, (2) Creative thinking skills, (3) Ethics, (4) Instructional design (5) Innovativeness and (6) Virtual learning environment. The fact that the TPACK scale was developed based on above-said competency areas is a factor increasing the originality value of the scale in related literature. In addition these competency areas and the resulted factors of the TPACK scale are similar. The 'Pedagogical skill' factor in the TPACK scale corresponds to 'Pedagogical skills' in TPACK competencies; 'creative thinking skills' to 'Creative thinking skills' the 'Ethical awareness' factor to 'Ethics' competency; the 'Virtual learning' factor to 'Virtual learning environment' competency; the 'Innovativeness' to 'Innovativeness' competency and the 'Instructional Design' factor to 'Instructional design'. The framework and factors of the TPACK scale based developed TPACK framework is figured out by Figure 2.

Figure 2. The framework and factors of the TPACK scale

As shown in Figure 2, the TPACK scale is based on the TPACK framework developed by Koehler and Mishra (2005). This scale is also highlighted on the TPACK component of the TPACK framework. The factors of the TPACK scale determined with explanatory factor analysis process. Teaching Skills factor refers to style of presenting the content, delivering the subject matter in effective way and applying appropriate technologies in order to enable efficient learning (Niess et al., 2009). Cognitive Skill factor refers to higher order of thinking and problem solving skills as well as improve and exhibit teacher leadership ability to integrate technology into the teaching and learning process by promoting and demonstrating the effective use of technological resources (Niess et al., 2009). Ethics factor refers to exhibiting legal and ethical behavior in the use of technology in teaching and learning environments in terms of both technology-related ethical issues and teacher professional issues (ISTE, 2000, 2008). Virtual learning factor refers to prepare lesson through electronic tools, making educational apps and track on student's performances by integrating technology into the teaching and learning process (Niess et al., 2009). And lastly, Design factor in the scale refers to creating and developing curriculum plans, teaching and learning environments as well as combining appropriate technological tools and resources to maximize learning in content (Niess et al., 2009).

Furthermore after identifying the factors, Cronbach's Alpha coefficients of internal consistency were calculated in order to check the reliability of the subscales and the whole scale. The Cronbach's Alpha coefficients for the 1st, 2nd, 3rd, 4th, 5th, and 6th factors of TPACK scale were calculated as .92, .87, .86, .91, .88, and .82 respectively and the Cronbach's Alpha coefficient for the whole scale was calculated as .84. While the reliability of the 1st and 4th factors as well as whole scale were considered as 'excellent' and the reliability of 2nd, 3rd, 5th and 6th factors were considered as 'very good' (Kline, 2005). In addition, the Cronbach's alpha coefficient values for pedagogical skills, creative thinking skills, ethics, instructional design, innovativeness and virtual learning environment of the scale

ranged between .82 to .92. Thus, the items within each factor of the scale were found to be consistent. Based on this result and in comparison, with the Cronbach's alpha coefficient values for other TPACK surveys in the literature as a whole and for their sub-dimensions (Archambault & Barnett, 2010; Sahin, 2011; Schmidt et al., 2009), the TPACK scale developed here can be said to have a high level of reliability in terms of its factors and as a whole. The results obtained in the present study demonstrated that the developed TPACK scale (Appendix A) could be a powerful instrument for measuring the teacher educators' TPACK.

Research implications

This study has methodologically contributed to the existing literature on TPACK framework. The scale developed can be useful to measure the TPACK competencies of school, college and university teachers in today's altering and turbulent environments. With swiftly altering educational environments, in contrast with the traditional teaching, teachers communicate broadly on both online and offline sources. Therefore the results of this study provide an absolute coverage and understanding of various touch points used in measuring TPACK (Technological pedagogical content knowledge).

Firstly Integration of technology, content and pedagogy knowledge (TPACK) helps the school, college and university teachers to teach effectively in the present scenario. TPACK helps the teachers to update their knowledge and skills which leads to enrich their professional progress. Secondly technology enhanced class room climate promotes confidence among learners, encourage to learn, easy to access at their convenience and long term retention will be there. Thirdly TPACK classroom climate provides the teacher and students to interconnect (share knowledge, ideas, views, opinions) with others locally and globally. This will help academic institutions in understanding the whole journey of TPACK and its impact on the professional development of the teachers. Fourth, the scale would be quite significant from strategic point of view. The educational institutions can find out the relative importance of all these 6 factors in assessing TPACK (Suryasa et al., 2019; Carson & Bedeian, 1994; Corcoran, 1995).

Along with the academic field this scale will also help the human resource practitioners to shift their energy, time and focus on the most important factors even with limited resources and time at their disposal. This will help them to analyze and access discrepancies, channelize feedback, thereby helping management in taking the corrective actions whenever necessary. However, this scale can also be used to access strengths and weaknesses of one academic institution relative to its competitors.

Limitation and scope for future research

Limitations

This study presents a step-by-step and systematic approach followed for development of reliable and valid scale for measure teacher educators' TPACK. Although, the TPACK scale developed in this study includes some shortcomings.

Firstly, this study was conducted with a survey research model and assembled research data with a scale form. Although a survey methodology is appropriate to inspect characteristics from a population, it is not as accurate as observing behavior and perception (Archambault & Barnett, 2010). Secondly, it was noticed in a part of the experimental studies carried out to observe the development of teacher educators' TPACK that there were slightly more male respondents (Chai et al., 2010; Lee & Tsai, 2010). Therefore, it could be said that the gender-rate of participants would be not influence the results of this study.

Thirdly, with the present study, it was developed a five-dimensional scale based on TPACK component of TPACK framework. The other phase in a scale development process is to propose a model by using structural equational modeling (SEM) (Netemeyer et al., 2003). Fourth, the findings of the study does not report on the long-term impact of TPACK competencies on teacher-educators as technology alters very rapid and how teacher-educators will be able to update their skills, classroom content and mode of delivery frequently. Lastly, this study did not include of creating a model from the developed scale, this study represents an important step in beginning to reach TPACK model. This study is the first step of a scale development procedure only. The next step, Confirmatory Factor Analysis (CFA) in order to confirm the factor-structure of scale did not carry out.

Future studies

The present study has a quantitative research design that aims at developing a scale in order to measure teacher-educators' TPACK. Based on the items of the scale created in the present study, case studies based on qualitative research that aim at further investigation of teacher educators' TPACK can be developed. In order to examine teacher educators' TPACK developments in detail and in a longer period of time, various follow-up research studies may be designed. The findings obtained via such applications and studies will provide a scientific insight for further development of the TPACK framework.

Several aspects can be considered in future studies. The present study developed that TPACK (Technological pedagogical content knowledge) competencies scale in order to measure teacher educators' TPACK in Punjab region. It can be further conducted on teachers of other state as well as national level. The sample of the current study is the teacher-educators working in different teaching training colleges in Punjab region. The sample can be taken as pre-service teachers. This study can be used to further examine the influence of TPACK competencies on the academic achievement of students. In this study, TPACK competencies of teacher-educators were assessed through filling questionnaire by the teacher-educators but the actual implementation in class were not studied. In future research, the actual implementation of content material designed using TPACK competencies can be used to further understand teachers' design capacities of TPACK with respect to the educational outcomes produced. Some possible future studies could continue to track pre service teachers' TPACK development during their teacher preparation journey. This study made the attempt to measure teacher educators' TPACK. In future research, It will be worthwhile to extend this effort to monitor pre service teachers' complete TPACK development until the end

of student teaching. This type of longitudinal research effort will provide an opportunity for teacher preparation programs to evaluate how well they incorporate TPACK framework to prepare pre service teachers to teach with technology.

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Annexure A

TPACK Competency Scale

Sr. No.	Statements	SA	A	N	D	SD
1.	I can merge relevant techniques and methods with technology in order to present content effectively.					
2.	I can optimize the topic by using virtual labs and technological-based educational hardware and software.					
3.	I can instruct students in designing numerous technologies for home assignments and projects.					
4.	I can use technology to keep my content knowledge and skills updated.					
5.	I consider myself as leader in spreading the use of technological innovations in my future teaching community.					
6.	I consider myself to be creative and original in my thinking and behaviour.					
7.	My peer groups often ask me for advice or information.					
8.	I behave ethically in acquiring information via technology like audio records, video records, documents etc.,					
9.	I can use technology in every phase of the teaching and learning process by considering the copyright issues (e.g. license).					
10.	I use the research work or artwork of another person with mentioning the source and reference.					
11.	I download software, movies, music, etc., with copy rights that are available for free access.					
12.	I advise other teachers and administrators about cooperating in order to increase ethical ICT usage.					
13.	I can explain my thoughts regarding a topic convincingly and logically.					
14.	While a lesson is explained, I can concentrate on the lesson together with my thoughts.					
15.	I can stimulate learning power of the students rather than memorizing it.					
16.	Virtual learning environment makes teaching learning process effective and enable learners to compete with this era of changing technology,					
17.	I admire my own abilities to present creative choices and solutions.					
18.	Developing an open view about a problem at hand should always be a first priority.					
19.	I usually manage my lessons both offline and online by using features of virtual learning.					
20.	Virtual learning environment facilitates student to repeat entire lectures, or any component according to his/her pace.					
21.	E-learning is very economical for educational institutions to adopt.					
22.	Pedagogical skills build confidence in teacher and make efficient teaching-learning process.					
23.	I know how to keep students busy in classroom by various activities.					
24.	I can make precautions determining the individual differences of students.					
25.	I encourage students in collaborative learning.					
26.	I know how to assess students' performance in the classroom.					