

PEDAGOGY OF LEARNING

International Refereed/ Peer Reviewed Journal of Education

Vol. 8 (1) January 2022, 40-49, E-ISSN: 2395-7344

Abstracted and indexed in: Google Scholar, Research Bib,
International Scientific Indexing (ISI), Scientific Indexing Services
(SIS), WorldCat, Cite Factor, Impact Factor: 0.787(GIF)

Website: <http://pedagogyoflearning.com>

Recommended citation for this Article:

Arora, R. & Pany, S. (2022). Technological pedagogical and content knowledge (TPACK) and willingness to learn among elementary mathematics teachers. *Pedagogy of Learning*, 8 (1), 40-49. Available at: <http://pedagogyoflearning.com>. DOI: 10.46704/pol.2022.v08i01.005

Technological Pedagogical and Content Knowledge (TPACK) and Willingness to Learn among Elementary Mathematics Teachers

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Article DOI: [10.46704/pol.2022.v08i01.005](https://doi.org/10.46704/pol.2022.v08i01.005)

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Article Publication Date: 30 January 2022

ABSTRACT

After the initiative of Digital India, the pandemic and repeated shutdowns of schools have increased the pace of digitization. Subsequent to these alterations in our day to day lives, online education has become normal for everyone. But, majority of teachers faced the challenge of integrating technology in their teaching-learning process during this transition time. For appropriate integration of technology in teaching of any subject, a teacher requires an adequate level of Technological Pedagogical and Content Knowledge (TPACK) and willingness to learn new knowledge and skills. Considering the importance of mathematics at higher level of studies, this study attempts to examine the level of TPACK and willingness to learn of elementary mathematics teachers of government schools of state Punjab (India). Self-constructed and standardized tools were used for collecting data from 189 elementary mathematics educators. Results indicated that the elementary school mathematics teachers have moderate level of TPACK and willingness to learn. Furthermore, the level of TPACK of mathematics teachers is independent of their level of willingness to learn. Training programs and resources should be made available to the teachers for successful integration of technology.

Keywords: TPACK, Willingness to learn, Teachers, Mathematics, Technology.

BACKGROUND OF THE STUDY

The Indian education system has come a long way from the ancient ‘Gurukul’ to the modern Smart classes. The journey from ancient classroom to modern ones, involves one driving force i.e., ‘Integration of Technology’. This journey involved some additional driving forces like pandemic period, lockdowns which left no other option for schools except the integration of technology for covering the loss of learning.

The present study is an attempt to examine the level of Technological Pedagogical and Content Knowledge (TPACK) and willingness to learn among the elementary mathematics teachers of Government schools of Punjab. Furthermore, it also entails the study of influence of their willingness to learn on their level of Technological Pedagogical and Content Knowledge (TPACK).

Considering the knowledge required by the teachers in the 20th century, an idea of Pedagogical Content Knowledge (PCK) was given by Shulman in 1986. PCK involved the knowledge of pedagogy, knowledge of content and knowledge of appropriate pedagogy to be used for a particular content. In the 21st century, digitalization began to have hold over every aspect including education which led to the arousal of construct Technological Pedagogical and Content Knowledge (TPACK). An idea of TPACK was given by Koehler and Mishra in 2009. It is an extension of Pedagogical Content Knowledge (PCK) as it gives due importance to the teachers’ knowledge about technology and knowledge about appropriate technology for a particular pedagogy and particular content. TPACK involves primary forms of knowledge i.e., TK, PK and CK and secondary forms of knowledge i.e., TPK, TCK and PCK.

The primary forms of knowledge i.e., TK, PK and CK, TK refers to the knowledge about hardware, software and web 2.0 tools. PK involves the knowledge about different methods of teaching, classroom management and assessment techniques. CK includes the knowledge of a particular content. The secondary forms of knowledge are obtained through the interplay of primary forms of knowledge. PCK is the knowledge about different pedagogies used for the better understanding of content. TCK refers to the knowledge about appropriate technology suitable for a particular content and TPK involves the knowledge about technology in relation to the pedagogy used. It is not only the knowledge about these primary and secondary forms of knowledge which plays an important role in the better learning of students, but it is the proper integration of selected technology or pedagogy in a particular content that is most essential aspect to be taken care of by the teachers.

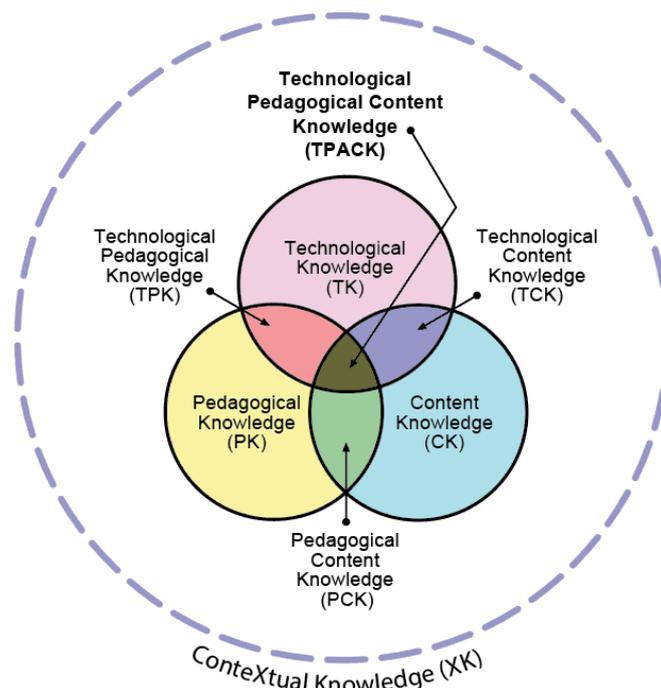
Mishra (2018) further updated the TPACK image by adding another component of knowledge i.e., ‘contextual knowledge’ (XK). The context is highly varying in every form of research e.g., the technologies available to the teachers, teachers’ knowledge of the school, district and state policies according to which the teachers have to function. The context can be understood as the organizational and situational constraints within which the teachers have to make efforts of integrating technology in their teaching-learning process. Thus, the teachers’ efforts in the direction of integration of technology largely depends on their contextual knowledge in comparison to the primary and secondary forms of knowledge. Thus, in future studies, where the teachers’ efforts towards integration of technology will be the main agenda of doing research, XK will be the most dominant component of knowledge.

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[Figure 1: Revised version of the TPACK image. © Punya Mishra, 2018. Reproduced with permission]

Thus, the pre-service and in-service mathematics teachers need to be equipped with the resources so that they can enhance their knowledge in these three domains i.e. technology, pedagogy and mathematics content. Although availability of resources is a significant factor in the development of mathematics teachers' TPACK, yet it is theorized that it is in the hands of teachers to update their TPACK if they are willing to learn about these three domains.

Willingness to learn means a desire or readiness to acquire new knowledge, skills or competencies. It involves both the situations i.e. professional and non-professional or general education. In the present study, teachers' willingness to learn refers to their desire to learn about new mathematical concepts, pedagogies and desire to acquire ICT competencies, experiment or use them in their classroom teaching-learning process. The teachers' willingness to learn new things is generally exhibited through their behavior. Such teachers are generally open-minded, pro-active and strive to discover new practices in their teaching-learning process.

LITERATURE REVIEW

Mathematics is considered as a difficult and dull subject by majority of the students (Langoban, 2020). Thus, mathematics needs to be taught to the students in an interesting manner by adding an element of technology in the classroom. National Council of Teachers of Mathematics (NCTM) has positioned that teachers are expected to provide a congenial environment in addition to the use of appropriate technology and pedagogy for a particular content for facilitating the learning of students (Cetin & Erdogan, 2018). NCTM had also stated that although, technology is used by the teachers but it is more used for finding online material or making presentations instead of integrating the technology in a particular content for better understanding of concepts by the students (Kartal & Cinar, 2018).

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The National Education Policy (NEP) 2020 has also reinforced the use and integration of technology in teaching-learning practices and suggested to adopt the inter-disciplinary STEM education in India. The STEM education will also require the skilled teachers who can do justice with the interdisciplinary approach of STEM curriculum. It is reported that incorporation of new technologies in education will not only change what the students learn, but also, how they learn. Thus, by integrating technology in their teaching-learning process, their learning can be enhanced by stimulating their interest in the concepts. For fulfilling these aims, the teachers are foreseen to attain an adequate level of Technological Pedagogical and Content Knowledge (TPACK) for making their teaching more effective.

Many studies have been conducted to assess the TPACK of pre-service and in-service teachers. The pre-service teachers are found to have an adequate level of TPACK but they need to know about effective integration of technology for better learning of students (Henriques & Gutiérrez-Fallas, 2017). One study in Indian context revealed that the teacher educators of Punjab (India) have high level of TPACK (Beri, Sharma & Kumar, 2019). Considering the mathematics teachers, the middle school pre-service teachers of an Australian school of education are found to be weak in mathematical content knowledge (Norton, 2019).

In addition to this, many experimental studies have been conducted for developing the TPACK of pre-service and in-service teachers. For instance, Cheng, Molina, Lin, Liu, & Chang, (2022) gave a new TPACK training model for improving online TPACK of pre-service teachers. In this new training model, Cloud Classroom (CCR) was integrated with the DEMO-CO-design/teach-feedback-DEbriefing (DECODE) model for improving pre-service teachers' online TPACK. The DECODE model involved four stages i.e., Teacher's Demonstrations, students CO-train in using Cloud Classroom, Students CO-design a Cloud Classroom-integrated course, Students CO-teach, and finally DE-brief what they have learnt during the previous stages.

In context to the teachers' willingness to adopt educational technology, it is expressed by most of the teachers that they are willing to learn (Kundu, 2018). It is also found in the study conducted by Eristi, Kurt & Dindar (2012) that teachers are willing to use technology while teaching their courses but they require constant support in using technology. Teachers face many problems while integrating technology in their classroom teaching like inadequate time for improving their technology related skills, inappropriate physical conditions etc. It is reported in a study conducted by Nguyen, Lee & Tan (2019) that the pre-service teachers become more willing and apply their learning with more confidence when they design technology-oriented activities. Further, Redmond & Lock (2019) found that the pre-service teachers have positive attitude towards integration of technology in the classroom

Thus, if the teachers have the desire to update their knowledge and skills for integration of latest technologies and pedagogies for teaching a particular content then the expected learning outcomes can be met by them.

RATIONALE OF THE STUDY

Now a days, schools are integrating technology in the classroom teaching by installing smart boards, LCD projectors in the classrooms. But, majority of the teachers are facing problems in using such technological devices because of many reasons like lack of training, lack of confidence in using technology etc. Such hurdles, coming in the way of appropriate integration of technology in the classroom, can be resolved by making the teachers efficient in

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incorporating technology in their teaching. Various initiatives are taken by the government of India in this direction of incorporating technology into the classroom teaching. These initiatives can prove to be successful only if the teachers are equipped with the requisite knowledge and skills related to technology, pedagogy and content.

In a study conducted by Ramanujam and Subramaniam (2012), it is shown that approximately 43% of mathematics teachers do not have any degree of college level. It indicates that they teach the mathematics subject with inadequate knowledge about methods of teaching for teaching mathematical concepts which may be the probable reason behind the poor performance of students in mathematics. Thus, mathematics teachers need to equip themselves with sound technological pedagogical and content knowledge and should be willing to learn latest innovations in the field of mathematics, technology and pedagogies. In context to India, there exist lack of resources in the government schools mainly which is an important contextual knowledge on the part of mathematics teachers. Thus, mathematics teachers are left with no other option except EDUSAT or mobile phones in context of technology use in their teaching-learning process. Further, as per ASER (2018) report, 78.7% schools of India do not have computers, which is an essential facility for integrating technology in mathematics teaching.

Such lacunas in the Indian education system and increasing demand of integration of technology in mathematics education, lead towards the need to ascertain the mathematics teachers' level of TPACK and level of willingness to learn for describing the present status of mathematics education in the government schools especially.

Objectives of the study

The present study purports to study the following:

- i. Level of Technological Pedagogical and Content Knowledge (TPACK) of elementary mathematics teachers
- ii. Level of willingness to learn among the elementary mathematics teachers
- iii. Interdependence of level of Technological Pedagogical and Content Knowledge (TPACK) of elementary mathematics teachers and their level of willingness to learn

Hypotheses of the Study

On the basis of the reviews related to literature, following hypotheses were formulated:

- i. Elementary mathematics teachers have average level of Technological Pedagogical and Content Knowledge (TPACK).
- ii. The elementary mathematics teachers have average level of willingness to learn.
- iii. The elementary mathematics teachers' TPACK is independent of their willingness to learn

METHODOLOGY OF THE STUDY

Population and Sample: The present study was conducted on the elementary mathematics teachers of upper primary government schools of Punjab teaching mathematics to 6th to 8th standard students only. For examining their level of TPACK and their level of willingness to learn i.e. the status of the phenomena; comprehensive mode of data were collected. Thus, survey method of descriptive type of research was employed in the present study. The 22

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districts of Punjab are spread over three sub divisions i.e., Majha, Malwa and Doaba. The investigator selected 8 districts of Punjab through simple random sampling. The investigator selected 2 districts from Majha, 4 from Malwa and 2 from Doaba through stratified proportionate sampling technique. Thus, covering the 176 schools of 8 districts of Punjab, the investigator obtained data from 189 elementary mathematics teachers of Punjab regarding their TPACK and willingness to learn.

Tools used for Data Collection: The tools used for collecting data from the elementary mathematics teachers regarding their TPACK and willingness to learn were constructed and standardized by the investigator. The tool ‘Technological Pedagogical and Content Knowledge Test for Mathematics Teachers’ having reliability of 0.70 was used for examining the level of TPACK. It consisted of 17 items under three categories i.e., Technological Knowledge (TK), Pedagogical knowledge (PK) and Content Knowledge (CK). It was a multiple-choice test having four options in each item. Teachers had to put a tick mark against their response.

The tool ‘Teachers’ Willingness to Learn Scale’ having reliability of 0.89 was administered for assessing the elementary mathematics teachers’ willingness to learn. It consisted of 20 items in statement form. It was a five-point scale with a response pattern of strongly agree, agree, neutral, disagree and strongly disagree. The teachers had to put a tick mark against their response.

Techniques of Data Analysis: The techniques to be followed for analyzing the data were decided after considering the nature of data collected in the present study. The level of mathematics teachers’ TPACK and their level of willingness to learn were found by using the application of normal probability curve. Through this application, whole range of scores were divided in to three parts i.e. high, average and low. Further, since the data of mathematics teachers’ level of TPACK and level of willingness to learn were categorical in nature, the interdependence between them was studied through non-parametric statistical technique i.e. chi-square test of independence.

RESULTS

The first objective of the present study was to examine the level of TPACK of the elementary mathematics teachers. The level of TPACK of the 189 elementary mathematics teachers was found after calculating their scores using the answer key of the test and interpreting their scores as per the range of scores given under each category i.e. high, average and low. The detail of number of mathematics teachers lying under different levels of TPACK is given in the table 1.

Table-1: Elementary mathematics teachers’ level of TPACK

S. No.	Level of TPACK	Number of Mathematics Teachers	Percentage
1.	High	68	36%
2.	Average	94	50%
3.	Low	27	14%
Total		189	100%

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From table 1, it is clear that majority (86%) of the mathematics teachers are lying in the category of average and high level of TPACK. Out of which, half of the mathematics teachers are having average level of TPACK. Further, it should be noted that very few mathematics teachers possess low level of TPACK. Thus, the hypothesis 'Elementary mathematics teachers have average level of Technological Pedagogical and Content Knowledge (TPACK)' is accepted.

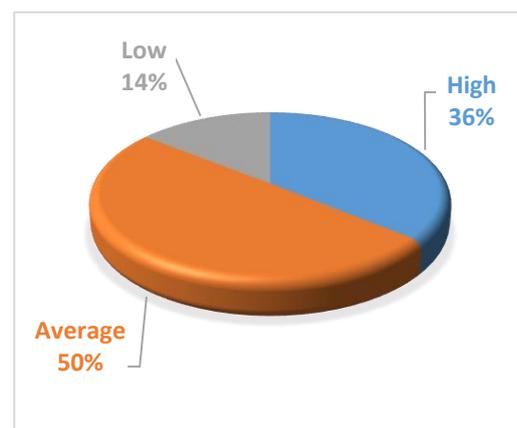
The second objective of the study was to reveal about the elementary mathematics teachers' level of willingness to learn. The scores obtained on the scale were calculated and interpreted against the range of scores given in the scale. The detail of number of mathematics teachers lying under each level of willingness to learn is given in the table 2.

Table-2: Elementary mathematics teachers' level of willingness to learn

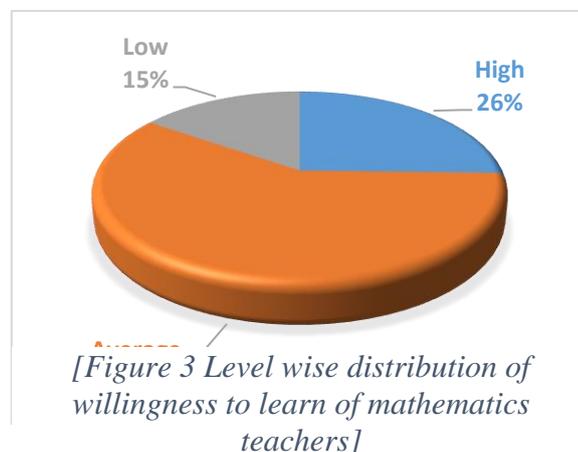
S. No.	Level of Willingness to learn	Number of Mathematics Teachers	Percentage
1.	High	48	26%
2.	Average	112	59%
3.	Low	29	15%
Total		189	100%

From table 2, it is clear that majority (60%) of the mathematics teachers are having average level of willingness to learn. Thus, the hypothesis 'The elementary mathematics teachers have average level of willingness to learn' is accepted.

The last objective of the study was to study the influence of elementary mathematics teachers' willingness to learn on their level of TPACK. Considering the categorical nature of data, chi-square test of independence was applied to see whether the elementary mathematics teachers' TPACK is independent of their willingness to learn or not. The result of chi-square test of independence is given in the table 3.



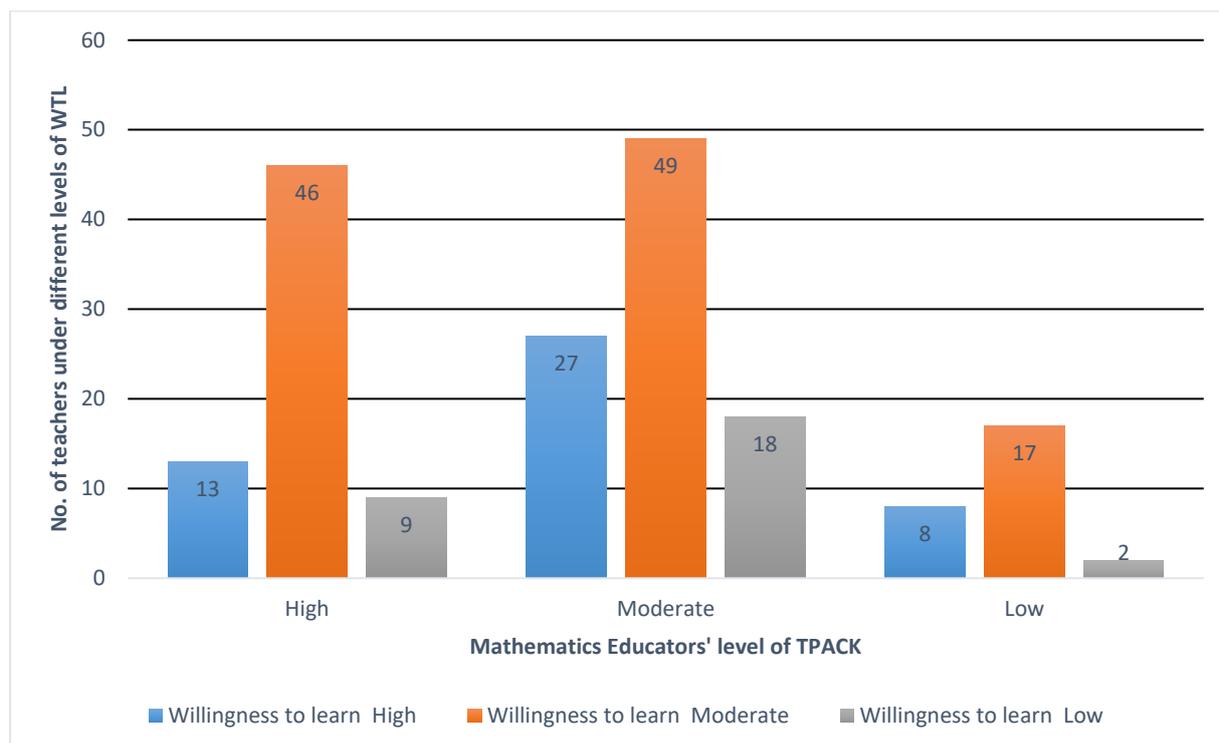
[Figure 2 Level wise distribution of TPACK of mathematics teachers]



[Figure 3 Level wise distribution of willingness to learn of mathematics teachers]

Table-3: Elementary mathematics teachers' level of willingness to learn and its influence on their level of TPACK

TPACK	Willingness to learn			Value of chi-square	Level of significance	Remarks
	High	Average	Low			
High	13	46	9	5.5247	At 0.05=0.237565	Not significant
Average	27	49	18			
Low	8	17	2			

*[Figure 4 Distribution of teachers' level of TPACK w.r.t. their willingness to learn]*

From table 3, it is found that the chi-square statistic is 5.5247. The p-value is .237565. Thus, the result is not significant at $p < .05$. It implies that the elementary mathematics teachers' TPACK is independent of their willingness to learn. Thus, the hypothesis 'The elementary mathematics teachers' TPACK is independent of their willingness to learn' is accepted. In other words, it can be said that willingness to learn does not influence the elementary mathematics teachers' TPACK.

DISCUSSION

Integration of technology in the teaching-learning process has become one of the popular areas for discussion in the field of education. For successful incorporation of technology, teachers should have sound knowledge in three domains i.e., Technology, Pedagogy and Content i.e., the teachers need to update their Technological Pedagogical and Content Knowledge (TPACK) with the changing demands of students and society. The present study was an attempt to examine the level of TPACK and willingness to learn among the

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elementary mathematics teachers. It was found that elementary mathematics teachers are having average level of TPACK. The present findings corroborate with the studies conducted by Koh, Chai & Tsai (2014) and Norton (2019).

Considering the results related to willingness to learn of elementary mathematics teachers, it is found that they possess an average level of willingness to learn. These results are in correspondence with the previous research conducted by Redmond & Lock (2019) on the pre-service teachers which highlights their readiness to develop their knowledge and skills of using latest technologies in the classroom.

Furthermore, the results indicate that mathematics teachers' willingness to learn does not influence their level of TPACK. Contrary to this, it is reported in the previous studies conducted by Nguyen, Lee & Tan (2019) and Redmond & Lock (2019) that the teachers' TPACK depends on their willingness to learn new things.

CONCLUSION

The Technological Pedagogical and Content Knowledge (TPACK) of elementary school mathematics teachers is very essential in the changing pedagogical context along with the willingness to learn new things. The study conducted by the investigator focused on the assessing the TPACK and willingness to learn among the mathematics teachers. The findings of the present study revealed the moderate level of TPACK and willingness to learn of majority of mathematics teachers which is a serious concern in this age of digitization. It also aimed to study whether the elementary mathematics teachers' TPACK is independent of their willingness to learn or not. The findings reported that mathematics teachers' willingness to learn does not influence their level of TPACK and the elementary mathematics teachers are having average level of TPACK and willingness to learn. The present findings suggest for further research to explore the factors which influence the TPACK of mathematics teachers. Furthermore, the present findings require similar research findings on a large sample of mathematics teachers for making a generalization about their level of TPACK, level of willingness to learn and their interdependence on each other.

EDUCATIONAL IMPLICATIONS

The moderate level of TPACK and willingness to learn among the mathematics teachers of government schools of Punjab (India), call for the prompt actions to be taken for the quality education in the 21st century. Therefore, it can be recommended that during pre-service teacher training program as well as in service training program, special focus need be given on how the teachers' willingness to learn as well as their level of TPACK can be developed.

The findings of the present study recommend that is need to provide opportunities to the in-service teachers for enhancing their knowledge and skills. Training may be given to the teachers and the resources may be made available to them for successful integration of technology in their classroom.

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