

Technological Pedagogical Content Knowledge (TPACK) among B.Ed. Trainees: A Comparative Study of Pre-Service and In-Service Teachers

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Abstract

Digital technologies have transformed educational practices, making it essential for teachers to effectively integrate technology with pedagogy and subject content. However, many B.Ed. trainees experience difficulties in integrating technological knowledge meaningfully into classroom instruction. The TPACK framework provides a comprehensive view of the pedagogical, technological and content knowledge needed for successful instruction in technology-supported learning environments. The study examined the Technological Pedagogical Content Knowledge (TPACK) of B.Ed. trainees and compared TPACK with respect to programme status and gender.

The study employed a descriptive survey method. Data were collected from 118 B.Ed. trainees studying in Government Teacher Education Institutions affiliated with Gauhati University using the TPACK Scale developed by Lata and Sharma (2017). Mean, standard deviation and independent-samples t-test were used for data analysis.

The findings revealed that the mean TPACK score of B.Ed. trainees was 192.99 with a standard deviation of 15.96, indicating an average level of TPACK competency according to the interpretation criteria of Lata and Sharma (2017). The study further revealed no significant difference in TPACK with respect to gender ($t = -0.712, p > 0.05$) and programme status ($t = 0.063, p > 0.05$). The study highlights the need to strengthen technology-integrated teacher education programmes through greater practical exposure to digital tools and technology-supported instructional practices. The findings may contribute to curriculum improvement and the development of effective training programmes for preparing future teachers for technology-rich classrooms.

Keywords: TPACK, Teacher Education, B.Ed. Trainees, Technology Integration, Pedagogical Knowledge.

Introduction

The rapid advancement of digital technologies has transformed educational practices and instructional processes across the world (Koehler et al., 2013; Voogt et al., 2013). Educational institutions increasingly

utilise online learning platforms, virtual classrooms, robotics, educational software, and artificial intelligence-based applications to improve teaching effectiveness and student engagement (Casler-Failing, 2021; Celik, 2023). Consequently, teachers

are expected to possess technological competences along with pedagogical and content knowledge for effective classroom instruction (Mishra & Koehler, 2006).

In this context, the Technological Pedagogical Content Knowledge (TPACK) framework has emerged as one of the most influential models for understanding technology integration in education (Koehler et al., 2013). The framework conceptualizes TPACK as the interaction among Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) (Mishra & Koehler, 2006). Effective technology integration therefore requires teachers to understand how technology, pedagogy, and content interact within teaching-learning environments (Voogt et al., 2013).

Several studies have emphasised the importance of teacher education programmes in developing TPACK competencies among pre-service teachers (Schmidt et al., 2009; Graham et al., 2012). Research findings indicate that TPACK-based instructional courses, collaborative learning experiences, and practical exposure to digital technologies positively contribute to the development of teachers' technological competencies (Durdu & Dag, 2017; Bueno-Alastuey et al., 2018; Wetzel et al., 2014; Tondeur et al., 2020).

Recent literature has expanded the scope of TPACK by integrating emerging technologies such as robotics and artificial intelligence into educational practices (Casler-Failing, 2021; Celik, 2023). Choi and Young (2021) proposed the TPACK-L framework emphasizing pedagogical design thinking for meaningful technology integration. Studies have additionally

shown that contextual factors such as institutional support, ICT barriers, and professional development opportunities significantly influence teachers' TPACK competencies (Rosenberg & Koehler, 2015; de Freitas & Spangenberg, 2019; Willermark, 2018). Dewi et al. (2021) and Zhang and Tang (2021) further reported the growing research interest in TPACK and digital pedagogies during the last decade.

Although several studies have examined TPACK in relation to technology integration and instructional effectiveness, limited studies have comparatively investigated TPACK competencies among pre-service and in-service B.Ed. trainees. Therefore, the present study aims to examine the level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. trainees and compare TPACK competencies with respect to gender and programme status.

Review of related Literature

The Technological Pedagogical Content Knowledge (TPACK) framework has emerged as one of the most influential frameworks for understanding technology integration in educational settings. Mishra and Koehler (2006) conceptualized TPACK as the interaction among technological, pedagogical, and content knowledge required for effective technology-supported instruction. Expanding this perspective, Koehler et al. (2013) explained that teachers need to understand the complex relationship among technology, pedagogy, and subject matter to facilitate meaningful learning experiences. Similarly, Voogt et al. (2013), through a comprehensive review of TPACK literature, highlighted

the framework's significance in guiding technology integration practices and teacher education programmes.

Several studies have examined the development of TPACK competencies among pre-service teachers. Schmidt et al. (2009) developed and validated a TPACK assessment instrument and reported that technological pedagogical competencies are essential components of teacher preparation. Graham et al. (2012) found that TPACK significantly influences teacher candidates' technology integration decisions and instructional planning processes. Likewise, Durdu and Dag (2017) reported that participation in TPACK-based courses positively improves pre-service teachers' technological understanding and pedagogical competencies.

Research has further highlighted the importance of collaborative and technology-rich learning experiences in enhancing TPACK competencies. Bueno-Alastuey et al. (2018) found that telecollaborative learning activities significantly contributed to the development of TPACK among pre-service teachers by providing authentic opportunities for technology-supported interaction and learning. Similarly, Wetzel et al. (2014) observed that the integration of educational technology into teacher education courses improved teachers' confidence, instructional skills, and technology integration practices. Tondeur et al. (2020) further emphasised that practical ICT experiences and collaborative learning opportunities positively influence the development of TPACK competencies among teacher trainees.

Contextual and environmental factors have also been identified as

important determinants of TPACK development. Rosenberg and Koehler (2015), in their systematic review, reported that institutional support, access to technological resources, and classroom contexts significantly affect teachers' technology integration practices. Similarly, de Freitas and Spangenberg (2019) found that ICT-related barriers, limited technological resources, and inadequate support systems hinder the effective implementation of TPACK in classroom instruction. Willermark (2018) further concluded that professional development opportunities and technological exposure play critical roles in enhancing teachers' TPACK competencies.

Recent studies have extended the TPACK framework to emerging technological domains such as robotics and artificial intelligence. Casler-Failing (2021) demonstrated that robotics-based instructional activities contribute to the development of technological knowledge and innovative teaching practices among teachers. Choi and Young (2021) proposed the TPACK-L framework, emphasizing pedagogical design thinking as an important element for effective technology integration. Furthermore, Celik (2023) introduced the concept of Intelligent-TPACK, highlighting the necessity of integrating artificial intelligence competencies into teachers' professional knowledge for effective AI-supported pedagogy.

The growing interest in TPACK research is evident from recent review studies. Dewi et al. (2021), through a systematic review of publications between 2010 and 2020, reported a substantial increase in TPACK-related research

focusing on technology integration, teacher education, and digital pedagogy. Similarly, Zhang and Tang (2021) reviewed the literature on TPACK development and concluded that technological competencies have become an essential component of teacher education in the digital era.

The reviewed studies collectively indicate that TPACK is a crucial determinant of effective technology integration, instructional effectiveness, and professional competence among teachers. Previous research has focused on conceptualizing TPACK, developing assessment instruments, examining teacher education programmes, exploring contextual factors, and integrating emerging technologies such as artificial intelligence and robotics. However, despite the growing body of literature, limited studies have specifically compared the TPACK competencies of pre-service and in-service B.Ed. trainees. Therefore, the present study seeks to examine the level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. trainees and compare TPACK competencies with respect to gender and programme status.

Objectives

1. To examine the level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. trainees.
2. To compare the Technological Pedagogical Content Knowledge (TPACK) of B.Ed. trainees with respect to:
 - a. Gender (Male and Female)

- b. Program Status (In-Service and Pre-Service)

Hypotheses

H₀₁: There is no significant difference in the Technological Pedagogical Content Knowledge (TPACK) between male and female B.Ed. trainees.

H₀₂: There is no significant difference in the Technological Pedagogical Content Knowledge (TPACK) between in-service and pre-service B.Ed. trainees.

Delimitation of the Study

1. The study is limited to Government Teacher Education Institutions affiliated with Gauhati University only.
2. The study includes only B.Ed. trainees studying in the second semester of the current academic batch.

Methodology

Research Design

The present study seeks to investigate the core knowledge domains of the TPACK framework and assess the level of technological pedagogical content knowledge among B.Ed. trainees. The present study adopts a descriptive survey method to examine the level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. trainees and analyse the different knowledge domains within the TPACK framework. The descriptive survey method is appropriate for this investigation as it allows the researcher to collect

information regarding the existing level of technological, pedagogical and content-related competencies of the respondents. This method helps in describing and interpreting the current status of TPACK among the participants in a systematic manner.

Population of the Study

The population of the present study consists of B.Ed. trainees studying in the

second semester in Government Teacher Education Institutions affiliated to Gauhati University. These trainees are undergoing professional teacher education and are being prepared to integrate subject knowledge, pedagogical strategies and technological tools in classroom teaching. Therefore, they represent an appropriate population for examining the level of Technological Pedagogical Content Knowledge (TPACK).

Table 1

Distribution of Govt. Teacher Education Institutions and Intake Capacity under Gauhati University

Sl. No	Type of Institution	Approved Intake
1	DIET, Sonitpur	50
2	DIET, Goalpara	50
3	DIET, Mirza	50
4	CTE, Nagaon	50
5	CTE, Mangaldoi	50
6	IASE, Guwahati	50
7	CTE, Tezpur	100
8	CTE, Goalpara	100
Total:		500

Thus, the total population of the study will be 500

Sample and Sampling Technique of the Study

A sample of 118 B.Ed. trainees studying in Government Teacher Education Institutions under Gauhati University was selected for the present study using the Stratified Random Sampling Technique. The population was stratified on the basis of gender and programme status (In-service and Pre-service) to ensure

proper representation of different groups. Thereafter, respondents were selected randomly from each stratum considering the feasibility of data collection, time constraints and accessibility of respondents.

Tools Used for Data Collection

The present study was conducted using the Technological Pedagogical Content Knowledge Scale developed by

Lata and Sharma (2017) to collect data. The scale is developed to measure technological pedagogical content knowledge among B.Ed. trainees. It consists of 55 items that address seven dimensions of the TPACK framework, including Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK),

Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPACK). Responses were collected on a five-point Likert scale ranging from Strongly Agree to Strongly Disagree.

Table 2
Scoring Procedure for the TPACK Scale

S. No.	Responses	Scores
1	Strongly Agree	5
2	Agree	4
3	Undecided	3
4	Disagree	2
5	Strongly Disagree	1

(Source: Lata & Sharma, 2017)

Table 3
Interpretation and Classification of Raw Scores for Total TPACK

Sl. No.	TPACK Raw Score Range	z-Score Range	Grade	Level of TPACK
1	270 & above	+2.01 & above	A	Extremely High
2	232 - 269	+1.26 to +2.00	B	High
3	195 - 231	+0.51 to +1.25	C	Above Average
4	144 - 194	-0.50 to +0.50	D	Average
5	107 - 143	-1.25 to -0.51	E	Below Average
6	69 - 106	-2.00 to -1.26	F	Low
7	68 & below	-2.01 & below	G	Extremely Low

(Source: Lata & Sharma, 2017)

Procedure of Data Collection

The data were collected from B.Ed. trainees studying in Government Teacher Education Institutions affiliated to Gauhati University. The TPACK scale was administered to the selected respondents after explaining the purpose of the study. The participants were requested to read each statement carefully and respond honestly. Adequate time was provided for completing the questionnaire. After completion, the filled-in questionnaires were collected and organised for further analysis.

Statistical Techniques Used for Data Analysis

In order to achieve the objectives of the study and to test the formulated hypotheses, appropriate statistical techniques were used for the analysis of the collected data. Both descriptive and inferential statistics were applied to interpret the responses obtained from the B.Ed. trainees.

The following statistical techniques were used:

1. **Frequency and Percentage:** Used to present the demographic characteristics of the respondents such as gender, stream, and programme status.
2. **Mean:** Used to determine the average

level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. trainees.

3. **Standard Deviation (SD):** Used to measure the variability of the scores around the mean.
4. **Independent Sample t-test:** Used to compare TPACK scores with respect to gender (male and female) and programme status (in-service and pre-service).
5. **Level of Significance:** All hypotheses were tested at the 0.05 level of significance.

Analysis and interpretation of data

Objective.1: To examine the level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. trainees.

Descriptive statistical techniques such as mean and standard deviation were employed to analyse the total scores gained by the respondents to study the level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. trainees. This analysis allows us to know the overall level of TPACK competency of the trainees.

The results of the analysis are presented in Table 4.

Table 4
Descriptive Statistics of TPACK Scores

N	Mean	Standard Deviation
118	192.99	15.96

Interpretation

The analysis of TPACK scores of B.Ed. trainees shows that the mean score is 192.99 with a standard deviation of 15.96. Based on the classification criteria, this score falls within the 144-194 range, indicating an Average level of Technological Pedagogical Content Knowledge. This suggests that the trainees possess a moderate level of

competence in integrating technology with pedagogy and content.

Objective 2(a): To compare TPACK with Respect to Gender

H₀₁: There is no significant difference in the Technological Pedagogical Content Knowledge (TPACK) between male and female B.Ed. trainees.

Table 5
Group Statistics of TPACK by Gender

Gender	N	Mean	SD
Male	77	192.19	15.21
Female	41	194.49	17.38

Table 6
t-test for Comparison by Gender

Variable	t-value	df	Sig. (2-tailed)	Result
TPACK (Gender)	-0.712	72.87	0.479	Not Significant

Interpretation

The data presented in Table 5 and Table 6 indicate that the mean TPACK score of female trainees (Mean = 194.49) is slightly higher than that of male trainees (Mean = 192.19). However, the calculated t-value (-0.712) with a p-value of 0.479 is greater than 0.05, indicating that the difference is not statistically significant. Therefore, the null hypothesis (H₀₁) is not rejected,

indicating that there is no significant difference in TPACK between male and female B.Ed. trainees.

Objective 2(b): To Compare TPACK by Programme Status

H₀₂: There is no significant difference in the Technological Pedagogical Content Knowledge (TPACK) between in-service and pre-service B.Ed. trainees.

Table 7
Group Statistics of TPACK by Program Status

Program Status	N	Mean	SD
In-Service	58	193.09	14.47
Pre-Service	60	192.90	17.41

Table 8
Programme Status Comparison

Variable	t-value	df	Sig. (2-tailed)	Result
TPACK (Program Status)	0.063	113.47	0.950	Not Significant

Interpretation

Table 7 and Table 8 show that the mean TPACK scores of In-service (Mean = 193.09) and pre-service trainees (Mean = 192.90) are nearly equal. The calculated t-value (0.063) with a p-value of 0.950 is greater than 0.05, indicating that the difference is not statistically significant. Hence, the null hypothesis (H_0) is accepted, revealing that there is no significant difference in TPACK between in-service and pre-service B.Ed. trainees.

Based on the objective-wise and hypothesis-wise analysis, it can be concluded that B.Ed. trainees possess an average level of TPACK and no significant differences exist with respect to gender and programme status. This indicates a relatively uniform distribution of technological pedagogical competencies among the trainees.

This may be because both groups were studying under a similar teacher education curriculum and were exposed to comparable technological resources, instructional practices and digital learning experiences during their training programme. Furthermore, the increased use of digital technologies and online learning

platforms may have provided both groups with similar opportunities to develop technological pedagogical competencies.

Major Findings

The major findings of the study based on the analysis and interpretation of data are as follows:

1. The mean score of TPACK of B.Ed. trainees was found average as indicated by the mean score of 192.99. This indicates that the trainees have a moderate competency in the integration of technology with pedagogy and content in the teaching learning process.
2. The analysis of TPACK based on gender showed that there is no significant difference between male and female B.Ed. trainees. The female trainees had a slightly higher mean score than the male trainees, but the difference was not statistically significant.
3. Comparison of TPACK with respect to programme status (in-service and pre-service) shows that there was no significant difference between the two groups. The levels of TPACK

- of in-service and pre-service trainees were almost similar.
4. The findings further indicate that TPACK competency is uniformly distributed among B.Ed. trainees irrespective of their gender and programme status.
 5. Overall, the results highlight that while trainees possess a moderate level of technological pedagogical competence, there is a need for further enhancement through training, exposure and integration of digital tools in teacher education programmes.

Educational Implications

The findings of the present study have several important implications for teacher education, curriculum planning, and classroom practices:

1. The finding that B.Ed. trainees possess an average level of TPACK indicates the need to strengthen technological integration in teacher education programmes. Teacher training institutions should place greater emphasis on developing digital pedagogical competencies among trainees.
2. Since no significant differences were found with respect to gender and programme status, it implies that TPACK development is not influenced by these variables. Therefore, training programmes can be designed uniformly while ensuring equal opportunities for all

trainees.

3. The moderate level of TPACK suggests that trainees require more hands-on experience with digital tools, such as Learning Management Systems (LMS), smart classrooms and educational software to enhance their teaching effectiveness.
4. Teacher educators should encourage the use of learner-centred and technology-integrated teaching strategies to promote effective application of TPACK in classroom instruction.
5. The findings highlight the importance of incorporating TPACK-based training modules into the B.Ed. curriculum to prepare future teachers for technology-rich learning environments.
6. Continuous professional development programmes and workshops should be organised for both pre-service and in-service teachers to update their technological knowledge and pedagogical practices.

Recommendations

Based on the findings, the following recommendations are suggested:

1. Teacher education institutions should introduce structured training programmes on TPACK, focusing on the integration of technology with pedagogy and subject content.
2. The B.Ed. curriculum should be revised to include more practical components, such as ICT-based

lesson planning, digital content creation and the use of interactive teaching tools.

3. Institutions should ensure the availability of adequate technological infrastructure, including computers, internet facilities, smart boards and digital resources.
4. Regular workshops, seminars and training sessions should be conducted to enhance the technological competencies of teacher trainees.
5. Teacher educators should encourage trainees to use technology in micro-teaching and practice teaching sessions, thereby bridging the gap between theory and practice.
6. Collaboration with schools and educational organizations should be promoted to provide real-life exposure to technology-integrated teaching environments.
7. Further research may be conducted by including additional variables such as teaching experience, digital literacy, attitude towards technology and institutional support to gain deeper insights into TPACK development.

Conclusion

The present study was conducted to determine the level of Technological Pedagogical Content Knowledge (TPACK) among B.Ed. Trainees and to compare it on the basis of Gender and Program Status. The findings of the study revealed that the level of TPACK of B.Ed. trainees

is average. It indicates that B.Ed. trainees have a moderate level of competence in integrating technology into pedagogy and their respective subject content.

The comparative analysis showed that there is no significant difference in TPACK with respect to gender, suggesting that both male and female trainees have comparable levels of technological pedagogical competencies. Similarly, no significant difference was found between in-service and pre-service trainees, indicating that programme status does not significantly influence TPACK levels. These findings suggest that TPACK is uniformly distributed among B.Ed. trainees, irrespective of their demographic and professional background. However, the average level of TPACK highlights the need for further improvement in integrating technology effectively into teaching practices.

In the context of the rapidly evolving digital era, it is essential for teacher education programmes to focus on enhancing the technological, pedagogical and content knowledge of trainees. Strengthening TPACK competencies will enable future teachers to create more engaging, effective, and technology-rich learning environments.

Overall, the study underscores the importance of continuous training, curriculum enhancement, and practical exposure to digital tools in order to prepare competent teachers who can meet the demands of 21st-century education.

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