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Research Article

Technological Correlates Of Teaching Performance Among Student-Teachers

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ABSTRACT

The present study investigates the relationship between technological pedagogical and content knowledge and teaching performance in the colleges of education. A survey method and random sampling technique is used to select a sample of 867 student-teachers. The research tools used are Technological Pedagogical and Content Knowledge Scale (Adapted from Kartal et al., (2016) and modified by the investigators) and Teaching Performance Scale developed by the investigators. The results of the statistical analyses show a significant correlation between technological pedagogical and content knowledge and teaching performance in the colleges of education. However, significant differences were observed among student-teachers at the colleges of education pertaining to their technological pedagogical and content knowledge and teaching performance.

Keywords: Technological, Pedagogical, Content, Knowledge, Teaching Performance, Student-teachers

1. Introduction

Learning has evolved over time, and so are the teaching methodologies. From time to time, educational needs and its relevance to society have undergone tremendous changes. From 'recital of epics' to 'rote memory'; from 'transcribing the manuscript' to writing 'commentaries'; from 'home tutoring' to 'school-based curriculum'; from 'localized learning material' to 'universal learning material'; from individual 'guru' based assessment to 'common assessments'; from 'one teacher' offloading his/her knowledge to 'multiple specialists' engaging in teaching; from 'teacher-centric' approach to 'student-centric' approach; from the confines of 'textbooks' to the openness of 'internet exposure' – teaching has come a long way. Despite the changing times and their needs, the fundamentals of 'teaching pedagogy' have remained consistent with the primary objective of teaching students with the right knowledge and enhanced techniques.
A decade ago, a typical teacher needed to be good at 'subject matter expertise' and possess the mastery of 'teaching pedagogy'. Considerable efforts and time have been spent by the teacher educator to equip the student-teachers with 'in-depth' knowledge of one's subject; encouraging them to attend as many seminars and workshops as possible to both widen and deepen the subject matter expertise. Research on teaching performance aids Teacher Education Programmes and researchers endeavour to design the curricula of Teacher Education Institutions ensuring that pre-service teachers are not only familiar with pedagogical theory but also trained in the practical skills needed to succeed in complex classroom environments. (Stronge, 2018). In the emerging scenario, it is mandatory to analyse how educators would be adapting with trending challenges such as online learning, blended learning, inclusive education, etc. With diverse classroom settings embedded with technology, the competencies of teachers need to expand with excellence.

2. Need for the current research

Teaching has gone beyond the confines of educational institutions and the classrooms. The advent of computer technology, coupled with IOT (Internet of Things) environment, has opened up new possibilities for learning for both the teaching faculty and student community. The infusion of technology into education has brought in some excitement and also some anxieties. Both the learners and teachers need to pick up new skills to maximize the benefits of technological introduction. Though the use of multimedia in the form of audio-visuals for learning has been there for decades, its use has been restricted to certain standardized videos were made and approved by the school management can only be displayed to the student community.

The televised version of UGC programmes are more towards the national level exposure on the subject matter. The direct involvement of the teaching community came in with the use of Power Point Slides, which a teacher prepares for the specific class and the set of students.

But the use of digital content from online and virtual classrooms have necessitated that the teachers remain at the helm of these technological tools to take advantage of it. The students are 'digital natives' and hence they easily get adapted to the usage of technology; whereas their teachers are mostly 'digital immigrants' lost out in the labyrinth of ever widening possibilities of using digital platforms, online resources, international contents, online assessment methods. So the teaching community needs to quickly get both in-depth knowledge and hands-on experience of educational technology available at its vicinity. Without adequate exposure and training into computer skills, the teacher will terribly fail in his/her duties and he/she can be ineffective in teaching the subjects. It is akin to olden days of 'learning to use the blackboard or ability to correct the class works of every student' – the computer technology has become an essential part of todays and future teachers.

3. Review of Related Literature

Studies reviewed pertaining to the present study have been compiled and presented below under appropriate headings.

3.1 Studies Related to Teaching Performance

As the function of teachers is becoming critical not just for professional advancement of students, but for personal development too, operative instruction has been an area of growing interest. Therefore, findings regarding teacher performance that the investigator has analyzed are compiled and presented in the following pages.

Sinha et al. (2016) revealed a study on Teacher Performance in Bihar, India: Implications for Education. The efficacy of teachers in India is essential for enhancing educational results. Enhancing Teacher Effectiveness in Bihar SURE initiative prioritizes professional development, performance monitoring, and innovative finance to improve accountability and service delivery, eventually striving for superior learning results across all educational tiers

Wambugu (2019) carried out a study on Student Teachers' Achievement in General Methods of Teaching Course that relates with their performance in Teaching Practice in University Education. This study examined the correlation by utilizing a random sample of 200 third-year education students from Egerton University's 2015/2016 cohort. Data was analyzed with SPSS, utilizing the Pearson product-moment correlation at a significance threshold of $\alpha=0.05$. The results indicated a statistically significant positive correlation ($r=0.226$, $p=0.004$) between success in the general methods of teaching course and performance in teaching practice. The study underscores the necessity for meticulous scrutiny of teaching methodologies, the incorporation of contemporary pedagogical strategies, and sufficient resource distribution to improve the quality of teacher training. It advises Egerton University to enhance preparation in methodologies courses and augment resource allocation to elevate teacher effectiveness and quality.

Dhana Raju and Vijaya Vardhani (2020) researched how self-efficacy and teacher effectiveness are related among secondary school teachers. Teacher effectiveness is regarded as a composite of the traits or features of a teacher such as skills, competencies, classroom instruction, knowledge and practical mastery over pedagogical techniques, evidence of improvement and growth made in curriculum transaction, participation in extra instructional activities and practice of ethics of teachers. Following the defined criteria, a sample of one hundred secondary school teachers from all types of secondary schools in YSR Kadapa district of Andhra Pradesh state was chosen. Teacher self-efficacy and teacher effectiveness revealed a clear correlation in the findings.

Brown et al. (2021) examined How pre-service teachers' sense of teaching efficacy and preparedness to teach impact performance during student teaching. This study sought to investigate the correlation between early childhood and elementary pre-service teachers' sense of teaching efficacy, emotions of preparedness, and their actual performance and it was found to be significant.

Kanya et al. (2021) sought to examine teacher performance in relation to organizational culture, school principle leadership, and teacher competency. Another goal was to find the degree of influence these elements provide for teachers. Using proportionate stratified random sampling, 525 teachers from Bandung High School were chosen for the study and it revealed a notable impact on organizational culture, teacher competency on teacher performance, and principal leadership factors of schools.

Singh et al. (2023) studied the Interpersonal Relationship of Student-Teachers in relation to their Academic Performance and Teaching Skills. This study examined the interpersonal interactions among final year Bachelor of Education students belonging to Meerut District, Uttar Pradesh, who engage with diverse stakeholders, including school kids, educators, non-teaching personnel, principals, teacher trainers, and colleagues, throughout their internship. For the sample of 204 candidates, a self-constructed and standardized Professional Interpersonal Relationship Scale was employed for data analysis. The results indicated a favorable association between student-teachers' interpersonal relationships and their academic performance and they suggested that enhanced interpersonal ties lead to greater academic outcomes. No

association was identified between interpersonal relationships and teaching skills, indicating that teaching skills are cultivated through practice and training rather than interpersonal interactions.

Evaluation

Although several studies have explored the relationship between teaching efficacy, teaching performance, and teacher self-efficacy, there remains a noticeable gap in the integration of these variables within diverse educational contexts, particularly in teacher preparation programs. The existing literature, such as the works of Weshah (2012), Poulou (2017) and Dhana Raju & Vijaya Vardhani (2020), primarily focuses on individual factors—such as locus of control, self-efficacy, or organizational support—in isolation. However, there is limited research that comprehensively examines how these variables interact within techno-pedagogical environments or within rapidly evolving digital classrooms. Moreover, many studies are region-specific and often lack comparative data that could offer insights into sustained teaching effectiveness across different educational levels. There is also a scarcity of studies that account for student-teacher emotional readiness, reflective practices, and digital competency as a combined framework for evaluating teaching performance. These gaps indicate the need for more integrative, context-sensitive, and technologically inclusive research models in teacher education

3.2 Studies Related to Technological Pedagogical and Content Knowledge (TPACK) and Teaching Performance

In an increasingly digital world, technological pedagogical and content knowledge has emerged as a critical competency for educators, students, and professionals alike. As technology permeates every aspect of life and learning, understanding its implications, applications, and ethical considerations has never been more vital. Technological pedagogical and content knowledge encompasses not only knowledge but also an understanding of how to integrate technology effectively into various contexts. The swift progression of technological innovation presents problems, requiring continuous professional growth and flexible learning approaches. Studies have shown that educators with a strong understanding of technology may improve student engagement, promote new teaching methods, and prepare students for a future that requires digital literacy.

Thohir et al. (2021) led the research work with an objective of exploring the relationship between the personality traits and TPACK Web of pre-service teachers. The data was collected from the sample of 309 pre-service teachers from nine different universities, who were selected by using random sampling technique. The analysis of the collected data revealed that there exists a significant correlation between the personality traits and TPACK web. Further it was also recommended in the present research work that there is need to develop the favorable traits before integration of web based TPACK competencies among pre-service teachers.

Ismaeel and Mulhim (2022) researched E-teaching Internships and TPACK during the Covid-19 Crisis: The Case of Saudi Pre-service Teachers to assess the impact of pre-service teachers' TPACK abilities for electronic teaching internship method and for the conventional face-to-face teaching internship strategy. About 120 prospective teachers of Saudi Arabia from two sessions 2019 (traditional) and 2020 (electronic) participated in the study. The results indicated significant differences between the two research groups regarding TPACK and they advocated the importance of blending traditional and online learning.

Qiu et al. (2022) conducted a study on Pre-service teachers' perceptions of technological pedagogical content knowledge in Mainland China: A survey of teachers with Chinese as a second language. The study investigated the TPACK factor structure of 286 pre-service TCSL teachers via exploratory factor analysis, which capitulated a six-factor structure. The results revealed that the teachers could not refine the boundaries between technological pedagogical knowledge (TPK) and technological content knowledge (TCK), and TPK and synthesized TPACK. Further, confirmatory factor analysis using structural equation modeling authenticated the validity and reliability of the adapted 32-item TCSL TPACK survey instrument. The study also found that the teachers were slightly satisfied with their overall TPACK but were least confident of their technological knowledge (TK), and the more experienced teachers exhibited tenacity in all six factors. These findings not only remind educators and policymakers of the need to revise current teacher training programs but also persuade TCSL student

Li et al. (2022) investigated on Differential Analysis of Teachers' Technological Pedagogical Content Knowledge (TPACK) abilities according to teaching stages and educational Levels**.** The results indicated that teachers' TPACK abilities were at a generally high level. Moreover, differences were found in the teaching phases and educational levels. The results suggested that the seven sub-dimensions of TPACK differed substantially according to teachers' educational levels, where the higher the educational level, the better the teachers' TPACK abilities. Therefore, teachers should effectively combine technology and apply suitable pedagogies according to the teaching content in different teaching stages. A series of ICT contemplates training courses for teachers with lower educational levels would be helpful to improve their self-confidence in using technology to promote their teaching effectiveness.

Relator (2022) researched on Educators in Loon, Bohol, who demonstrated an exceptionally high degree of Technological Pedagogical and Content Knowledge (TPACK) alongside a highly good teaching performance.

TPACK demonstrated a substantial association with the setting; however, it did not connect with teaching efficacy. Furthermore, the context and teaching performance exhibited an inconsequential association. This suggests that although educators possess substantial technological knowledge, it does not inherently result in enhanced instructional efficacy.

Berrocoso et al. (2022) investigated on the educational integration of digital technologies pre-Covid-19: Lessons for teacher education, a systematic research that demonstrates the use of Information and Communication Technologies (ICT) in educational practices, which results in enhanced academic achievement, especially in Mathematics and Science. Nevertheless, the majority of research employed conventional teaching approaches, with hardly a quarter integrating blended learning.

Onbasili et al. (2022) conducted a study on examination of pre-service teachers' experiences in creating a scientific digital story in the context of their self confidence in technological pedagogical content knowledge. This research, using a mixed model approach, was conducted with 24 fourth-grade pre-service teachers. In the study, the "Technological Pedagogical Content Knowledge Confidence Scale" (TPACK) was applied as a pre-test and post-test. The quantitative findings of the study revealed that the experiences of pre-service teachers in creating a scientific digital story increased statistically significantly in the TK dimension of the TPACK scale and in the TPACK total self-confidence scores. The qualitative findings of the research showed that it had a positive effect on TCK, TPK, and TPCK dimensions, as well as on the TK and total score of TPACK. In the light of these findings of the research, the use of digital stories in educational environments can be recommended since the use of digital stories in educational environments is effective in developing students' TPACK self-confidence perceptions.

Wu et al. (2022) investigated on Exploring secondary school teachers' TPACK for video-based flipped learning: the role of pedagogical beliefs. This study generally expressed ample confidence in their TPACK for VFL. They bear strong learner-centered pedagogical beliefs and moderate teacher-centered pedagogical beliefs. Besides, compared with the senior high school teachers, the junior high school teachers showed significantly higher confidence in their technological pedagogical content knowledge (TPACK) for VFL ($p < 0.05$). This study also found that the teachers' learner-centered pedagogical belief was significantly correlated with their content knowledge (CK), pedagogical knowledge (PK),pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK) ($p < 0.05$). In contrast, their teacher-centered pedagogical belief was significantly correlated with their TCK, TPK, and TPACK ($p < 0.05$). Cluster analysis was conducted based on the teachers 'pedagogical beliefs, which categorize three groups: the Learner-centered Group, the Double-emphasis Group, and the Neutral Group. A series of ANOVA confirmed that the three groups of teachers significantly differed in their CK, PK, PCK, and TPACK ($p < 0.05$), indicating that teachers' pedagogical beliefs rendered a role in their TPACK for VFL. A series of post hoc analyses further revealed that, in general, the teachers in the Double-emphasis Group (i.e., those teachers who held both strong learner-centered and teacher-centered pedagogical beliefs) showed better TPACK for VFL.

Ana et al. (2023) investigated TPACK model as a framework for in-service teacher training. It analyzes the level of teaching competence according to the TPACK model and the variables that influence technological implementation in the classroom. Research has proven that TPACK model can significantly contribute to teachers' training in their educational work, along with the training context, as well as to contribute to their initial training. The objective of this research is to analyze the level of teaching competence that teachers have according to TPACK model, as well as the variables that influence the technological implementation in the classroom. The questionnaire composed of 47 items divided into the seven dimensions of TPACK model and a stratified sampling by conglomerates in various stages was used by using public schools as a sampling unit. The sample is formed by 825 teachers. This is a descriptive and non-experimental investigation, where a multivariate analysis of variance (MANOVA) test between the dimensions of the diagnosis scale and the socio-demographic variables was done. The most significant results were the differences found between the educational stage and the age of the participants. It should be noted that the organization of the two stages, although based in the same principles and with common elements for the transition from one to another, is different. The study presents some adapted and focused training proposals in order to alleviate the training weaknesses of in-service teachers from TPACK model.

Evaluation

The studies related to relationship between TPACK and technology anxiety among student teachers show that more research is needed to explore factors influencing technology anxiety and how it might affect the development and application of TPACK in teacher education programs. Researches have highlighted the integration of design thinking with TPACK as a promising approach to enhancing critical thinking and creativity among students. Yet, the practical implementation of such integration remains underexplored, especially in diverse educational settings. Further empirical studies are necessary to evaluate the effectiveness and scalability of TPACK-integrated design thinking methodologies. Overall, these studies have contributed valuable insights into TPACK and technology use in education. Thus, there is a noticeable dearth of comprehensive research addressing the dynamic and contextual factors affecting TPACK development, sustained technology integration in teaching practice, and the impact of innovative approaches such as design

thinking within TPACK frameworks. Therefore, it becomes imperative to further investigate the impact of technology-related knowledge in assessing the teaching performance of student-teachers

4. Title of the Problem

The review done from the available relevant literature, relating to the present research area, led the investigators to conceptualize the problem in an attempt to fill in the lacunae found.
Thus, the problem is stated as here under:

Technological Correlates of Teaching Performance among Student-teachers.

5. Objectives of the Study

- To ascertain the extent of influence of technological pedagogical and content knowledge and teaching performance;
- To fulfill the objectives, to develop appropriate scales and inventories to assess the select variables of the study and
- To compare student-teachers on the select variables of study using classifications of categories of colleges of education and gender.

6. Hypotheses

(i) There will be a significant and positive relationship between technological pedagogical and content knowledge and teaching performance of student-teachers in different categories of colleges of education namely, government, government-aided, and self-financing colleges.
(ii) There will be no significant difference in technological pedagogical and content knowledge and teaching performance among student-teachers in different categories of colleges of education namely, government, government-aided and self-financing colleges.
(iii) There will be no significant difference in technological pedagogical and content knowledge and teaching performance among student-teachers with respect to gender.

7. Method of Investigation

The study involved multiple variables necessitating multiple permutations and combinations. The investigator took utmost care to establish a sound research methodology, designing the psychometric properties and executing the same to the sample. Normative survey was carried out and the samples were drawn through Random Sampling technique, which was followed by construction of tools.

7.1 Population and Sample Characteristics

The target population for the present study was the student-teachers at colleges of education. From the target population, a sample of 867 student-teachers was chosen from the chosen colleges of education. The sample comprised of 275 student-teachers from Government Colleges of Education, 294 from Government-aided Colleges of Education and 298 from self-financing Colleges of Education. Accordingly, 425 male student-teachers and 442 female student-teachers from different categories of colleges of education were chosen for the study.

7.2 Tools used for the Study

The variables chosen for the present study necessitated construction of a tool by the researchers and selection of another relevant tool. The tools used for assessment are as follows:

- Technological Pedagogical and Content Knowledge (TPACK) Scale
  (Adapted from Kartal et al. (2016) and modified by the investigators)
- Teaching Performance Assessment Scale (Developed by the investigators)

The tools chosen/ developed were found to be suitable, workable, reliable and valid.

8. Analyses of Data

The result of the analyses of data collected are compiled and presented in tables below:
Statistical analyses were based on the hypotheses formulated for the present study. It is envisaged to be multivariate statistical analyses as the study includes multiple variables.

Table - 1a Simple Correlation Matrix between the Selected Independent Variable and Teaching Performance of Male Student-teachers in Government Colleges of Education (N=135)

Variables	Technological Pedagogical and Content Knowledge	Teaching Performance
Technological Pedagogical and Content Knowledge	1	0.59**
Teaching Performance	X	1

****Significant at 0.01 level**

It is seen in the table above (Table-1a) that the independent variable, technological pedagogical and content knowledge correlate significantly and positively with the dependent variable, teaching performance of the male student-teachers in the government colleges of education.

Table – 1b Simple Correlation Matrix between the Selected Independent Variable and Teaching Performance of Female Student-teachers in Government Colleges of Education (N=140)

Variables	Technological Pedagogical and Content Knowledge	Teaching Performance
Technological Pedagogical and Content Knowledge	1	0.63**
Teaching Performance	X	1

****Significant at 0.01 level**

In the table above (Table-1b), it is seen that similar to the case of male student-teachers, in the case of the female student-teachers in the government colleges of education also, the independent variable, technological pedagogical and content knowledge correlate significantly and positively with the dependent variable, teaching performance of the female student-teachers in the government colleges of education.

Table – 1c Simple Correlation Matrix between the Selected Independent Variable and Teaching Performance of Male Student-teachers in Government-aided Colleges of Education (N=148)

Variables	Technological Pedagogical and Content Knowledge	Teaching Performance
Technological Pedagogical and Content Knowledge	1	0.59**
Teaching Performance	X	1

****Significant at 0.01 level**

It is seen in the table above (Table-1c), similar to the cases of both male and female student-teachers in government colleges of education, the independent variable, technological pedagogical and content knowledge correlate significantly and positively with the dependent variable, teaching performance of the male student-teachers in the government-aided colleges of education.

Table – 1d Simple Correlation Matrix between the Selected Independent Variable and Teaching Performance of Female Student-teachers in Government-aided Colleges of Education (N=146)

Variables	Technological Pedagogical and Content Knowledge	Teaching Performance
Technological Pedagogical and Content Knowledge	1	0.62**
Teaching Performance	X	1

****Significant at 0.01 level**

In the above table (Table-1d), as in the previous case, the independent variable, technological pedagogical and content knowledge correlate positively and significantly with the teaching performance of female student-teachers in government-aided colleges of education

Table – 1e Simple Correlation Matrix between the Selected Independent Variable and Teaching Performance of Male Student-teachers in Self-financing Colleges of Education (N=142)

Variables	Technological Pedagogical and Content Knowledge	Teaching Performance
Technological Pedagogical and Content Knowledge	1	0.78**
Teaching Performance	X	1

****Significant at 0.01 level**

In the above table (Table-1e), it is seen that the independent variable, technological pedagogical and content knowledge correlate significantly and positively with the dependent variable, teaching performance of the male student-teachers in the self-financing colleges of education.

Table – 1f: Simple Correlation Matrix between the Selected Independent Variable and Teaching Performance of Female Student-teachers in Self-financing Colleges of Education (N=156)

Variables	Technological Pedagogical and Content Knowledge	Teaching Performance
Technological Pedagogical and Content Knowledge	1	0.82**
Teaching Performance	X	1

****Significant at 0.01 level**

It is seen in the table above (Table-1f), that similar to the case of female student-teachers in government and government-aided colleges of education, in the case of the female student-teachers in self-financing colleges of education, too, the independent variable, technological pedagogical and content knowledge correlate significantly and positively with their teaching performance.

The groups compared were students (both male and female student-teachers) belonging to government, government-aided and self-financing colleges of education. The statistical analysis was computed using the technique of analysis of variance (Hair et al., 1998). The results have been presented in Table-2a, 2b and 2c.

The table presented below shows the analysis of variance computed with male and female student-teachers of government colleges of education.

Table-2a: Summary of Significance of Mean Difference between Male and Female Student-teachers in Government Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Male	135	129.07	17.78	1.53	2.63	12.05	0.001**
	Female	140	160.75	25.08	2.12			
Teaching Performance	Male	135	63.15	7.30	0.63	1.12	10.33	0.001**
	Female	140	74.79	10.96	0.93			

****Significant at 0.01 level**

It is seen from the above table (Table-2a) that comparing the male and female student-teachers in government colleges of education, there is a significant difference between male and female student-teachers pertaining to the independent and dependent variables. The female student-teachers are found to be significantly better than the male student-teachers pertaining to independent variable, technological pedagogical and content knowledge and the dependent variable, teaching performance.

Table – 2b: Summary of Significance of Mean Difference between Male and Female Student-teachers in Government-aided Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Male	148	179.19	20.73	1.70	2.36	2.60	0.010*
	Female	146	185.36	19.80	1.64			
Teaching Performance	Male	148	86.08	7.48	0.61	0.80	9.41	0.001**
	Female	146	93.63	6.20	0.51			

****Significant at 0.01 level** *** Significant at 0.05 level**

A picture similar to the comparison of male and female student-teachers in government colleges of education exists when comparing the male and female student-teachers in the government-aided colleges of education and the results are presented in Table-2b. Though there is significant difference between the male and female student-teachers pertaining to technological pedagogical and content knowledge, the female student-teachers are seen to be better than the male student-teachers

Table – 2c Summary of Significance of Mean Difference between Male and Female Student-teachers in Self-Financing Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Male	142	86.34	16.62	1.39	1.87	14.04	0.001**
	Female	156	112.6	15.71	1.26			
Teaching Performance	Male	142	40.85	6.30	0.53	0.76	16.07	0.001**
	Female	156	53.04	6.76	0.54			

****Significant at 0.01 level**

In the above table (Table-2c), it is seen that in self-financing colleges of education, when male and female student-teachers are compared, the female student-teachers are found to be significantly better than the male student-teachers pertaining to the variable, technological pedagogical and content knowledge and teaching performance similar to their counterparts in other two categories of colleges of education, the government and government-aided colleges of education. The table presented below provides a comparison of male student-teachers belonging to the three categories of colleges, namely, government, government-aided and self-financing colleges.

Table – 3: One-way Analysis of Variance for the Three Groups of Male Student-teachers belonging to Government, Government-aided and Self-financing Colleges of Education N=135 (Government) + 148 (Government-aided) + 142 (Private) = 425

Variables	Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	*F* value	Level of Significance
Technological Pedagogical and Content Knowledge	Between Groups	2	626778.09	313389.04	915.49	0.001**
	Within Groups	422	144458.83	342.32		
	Total	424	771236.91			
Teaching Performance	Between Groups	2	148349.46	74174.73	1493.21	0.001**
	Within Groups	422	20962.66	49.67		
	Total	424	169312.12			

****Significant at 0.01 level**

On comparing the male student-teachers in different categories of colleges of education, government, government-aided and self-financing colleges of education, it is evident that there exists a significant difference among male student-teachers pertaining to the independent variable, technological pedagogical and content knowledge and the dependent variable, teaching performance. The tables 3a, 3b and 3c clearly give the nature and direction of difference for explanation of the difference.

Table -3a: Summary of Significance of Mean Difference between Male Student- teachers in Government and Government-aided Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Government	135	129.07	17.77	1.53	2.3	21.7	0.001**
	Government-aided	148	179.19	20.73	1.70			
Teaching Performance	Government	135	63.15	7.30	0.63	0.88	26	0.001**
	Government-aided	148	86.08	7.48	0.61			

****Significant at 0.01 level**

It is seen from Table-3a, that the male student-teachers in government–aided colleges are significantly better than the male student-teachers in government colleges of education pertaining to the independent variable, technological pedagogical and content knowledge and the dependent variable, teaching performance. A similar comparison was made with the male student-teachers belonging to government and self-financing colleges of education and the results are presented below.

Table - 3b Summary of Significance of Mean Difference between Male Student-teachers in Government and Self-Financing Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Government	135	129.07	17.77	1.53	2.07	20.7	0.001**
	Self-financing	142	86.34	16.62	1.39			
Teaching Performance	Government	135	63.15	7.30	0.63	0.82	27.3	0.001**
	Self-financing	142	40.85	6.30	0.53			

****Significant at 0.01 level**

On comparing the male student-teachers in government and self-financing colleges of education, it is seen that the male student-teachers in government colleges are significantly better than the male student-teachers in self-financing colleges of education pertaining to the independent and dependent variables, technological pedagogical and content knowledge and teaching performance.

A third comparison has been made with the male student-teachers in government-aided and self-financing colleges of education and the results are presented below.

Table - 3c: Summary of Significance of Mean Difference between Male Student-teachers in Government-aided and Self-financing Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Government-aided	148	179.19	20.73	1.70	2.21	41.97	0.001**
	Self-financing	142	86.34	16.62	1.39			
Teaching Performance	Government-aided	148	86.08	7.48	0.61	0.81	55.57	0.001**
	Self-financing	142	40.85	6.30	0.53			

****Significant at 0.01 level**

On comparing the male student-teachers in government-aided and self-financing colleges, the male in government-aided are found to be significantly better than the male student-teachers in self-financing colleges of education pertaining to all variables, technological pedagogical and content knowledge and teaching performance.

The following analysis of variance was computed with a comparison of the three groups of female student-teachers belonging to government, government-aided and self-financing colleges of education.

Table – 4: One-way Analysis of Variance for the Three Groups of Female Student-Teachers belonging to Government, Government-aided and Self-financing Colleges of Education N = 140 (Government) + 146 (Government-aided) + 156 (Private) = 442

Variables	Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F value	Level of Significance
Technological Pedagogical and Content Knowledge	Between Groups	2	414871.24	207435.62	498.87	0.001**
	Within Groups	439	182540.93	415.81		
	Total	441	597412.18			
Teaching Performance	Between Groups	2	124654.49	62327.24	932.31	0.001**
	Within Groups	439	29348.28	66.85		
	Total	441	154002.77			

****Significant at 0.01 level**

In the above table (Table-4), the female student-teachers in all categories of colleges of education, government, government-aided and self-financing are compared. It is seen that there exists a significant

difference among female student-teachers pertaining to technological pedagogical and content knowledge and teaching performance.
The variables, manifesting differences among female student- teachers in the three different categories of colleges of education necessitated further analysis using critical ratios. The results have been presented in tables (Table-4a, 4b and 4c).

Table - 4a Summary of Significance of Mean Difference between Female Student-teachers in Government and Government-aided Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Government	140	160.75	25.08	2.12	2.67	9.23	0.001**
	Government - aided	146	185.36	19.80	1.64			
Teaching Performance	Government	140	74.79	10.96	0.93	1.05	17.99	0.001**
	Government-aided	146	93.63	6.20	0.51			

****Significant at 0.01 level**

In the above table (Table-4a), on comparing the female student-teachers in government and government-aided colleges of education it is observed that the female student-teachers in the government-aided colleges of education are significantly better than the student-teachers in government colleges of education pertaining to the independent variable, namely, technological pedagogical and content knowledge and dependent variable, teaching performance.
Table-4b presents the comparison among female student-teachers of government and self-financing colleges of education.

Table - 4b Summary of Significance of Mean Difference between Female Student-teachers in Government and Self-financing Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Government	140	160.7	25.08	2.12	2.41	19.98	0.001**
	Self-financing	156	112.6	15.71	1.26			
Teaching Performance	Government	140	74.79	10.96	0.93	1.05	20.77	0.001**
	Self-financing	156	53.04	6.76	0.54			

****Significant at 0.01 level**

As per the above table (Table 4b), on comparing the female student-teachers in government and self-financing colleges, like in the case of the male student-teachers, the female student-teachers in the government colleges of education are significantly better than the female student-teachers in self-financing colleges pertaining to the independent and dependent variables selected for the present study.

Table - 4c Summary of Significance of Mean Difference between Female Student-teachers in Government-aided and Self-financing Colleges of Education

Variables	Groups	N	Mean	SD	SEM	SED	CR	Level of Significance
Technological Pedagogical and Content Knowledge	Government-aided	146	185.36	19.80	1.64	2.05	35.47	0.001**
	Self-financing	156	112.64	15.71	1.26			
Teaching Performance	Government-aided	146	93.63	6.20	0.51	0.75	54.27	0.001**
	Self-financing	156	53.04	6.76	0.54			

****Significant at 0.01 level**

On comparing the female student-teachers in government-aided and self-financing colleges of education, it is seen in the above table (Table-4c) that the female student-teachers in government-aided colleges are significantly better than the female student-teachers in self-financing colleges of education pertaining to independent and dependent variables.

9. Discussion

The research indicates a favorable relationship between Technological Pedagogical and Content Knowledge (TPACK) and the teaching effectiveness of student-teachers, which supports findings from earlier studies (Singerin, 2022). This implies that specific interventions and improvements in the curriculum that focus on TPACK could substantially enhance outcomes in teacher education. Interestingly, female student-teachers consistently achieve better results than their male peers across all types of colleges (government, government-aided, and self-financing) in both TPACK and teaching performance. This is attributed to the greater normalization of technology for women in society, their tendency to thrive in collaborative learning environments bolstered by digital tools, a strong desire to incorporate technology into contemporary teaching practices, and a proactive approach to using institutional digital literacy initiatives. A comparison among various college types reveals that student-teachers in government-aided colleges perform better in TPACK and teaching effectiveness than those in both government and self-financing colleges. This advantage stems from the rigorous oversight of educators in government-aided colleges, continuous faculty development, and significant investment in technological resources and digital platforms by the management. While government colleges benefit from large-scale, centrally funded programs such as SWAYAM and NPTEL, their tighter budget constraints and bureaucratic procedures can impede their ability to swiftly adopt new technologies. Although self-financing colleges operate with more autonomy, their technology adoption is often inconsistent due to profit motives and dependence on student tuition, resulting in less thorough integration compared to the more reliably funded and adaptable government-aided institutions.

10. Conclusion

It was found that TPACK facilitates teaching performance of student-teachers and it provides an educator with all-encompassing framework to reflect on one's own effectiveness. An Educator or a teacher who has internalized this framework will be able to innately assess the gaps in her/his own approach and performance well as a teacher. TPACK provides a focal point for the educators/ student-teachers to engage in periodic soul-searching exercises to improve their own metacognition and also propels them to continuously seek, adopt and adapt new technologies and methodologies to enhance one's own reach and command as a teacher. It is definitely not an exaggeration to point out that the teacher hence becomes a life-long learner and his/her continued learning habit keep them abreast of current affairs and position them as a relevant friend, guide and philosopher to the student community in particular and the larger society in general.

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