



---

**PERCEPTION OF PRE-SERVICE TEACHERS TOWARDS TECHNOLOGICAL  
PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK)**

**SAIKIA J<sup>1\*</sup> AND PADMAVATHY RD<sup>2</sup>**

**1:** Research Scholar, Department of Education, Tezpur University (Central), Assam, India

**2:** Assistant Professor, Department of Education, Tezpur University (Central), Assam, India

**\*Corresponding Author: Juli Saikia: E Mail: [jsaikia96@gmail.com](mailto:jsaikia96@gmail.com)**

Received 17<sup>th</sup> Aug. 2020; Revised 16<sup>th</sup> Sept. 2020; Accepted 7<sup>th</sup> Oct. 2020; Available online 1<sup>st</sup> July 2021

<https://doi.org/10.31032/IJBPAS/2021/10.7.5588A>

**ABSTRACT**

This study has highlighted the importance of investigating the pre-service teachers' perception on Technological Pedagogical Content Knowledge. The study is to explore the perception of pre-service teachers towards the technology integration called Technological Pedagogical and Content Knowledge (TPACK) using normative survey method. Purposive sampling technique has been used in the selection of the sample of 170 pre-service teachers pursuing teacher training course in Sonitpur district, Assam, India. Technological, Pedagogical and Content Knowledge in pre-service teachers will help the pre-service teachers to develop and practice their technological skills, pedagogical skills and content skills in their teaching learning process. TPACK provides proper knowledge about what technology is to be used, what pedagogical techniques and methods are to be used and how the deep knowledge about the content is important. The findings of the study show that the majority of the pre-service teachers are having an average level of perceive techno-pedagogical competence.

**Keywords: Technological; Pedagogical; Content; Knowledge; Pre-service teachers**

**INTRODUCTION**

Education is the process of bringing a young for living a congenial and comfort life and the ultimate goal of education is progressive development of child. A

teacher is the influence person who can nurture the life, provide the information and bring out child to the light of knowledge. All education commissions and committee (Education commission 1952-

53, 1964-66, NPE 1986, NPE 2020 etc.,) National Council for Teacher Education a statutory body of Govt. of India argued for the quality development of the teacher education programme in India to produce good and effective teachers with the perception towards teaching. The professional preparation of teachers and promoting positive attitude towards teaching has been recognized to be crucial for the qualitative improvement of education since 1960s. The NCFTE 2010 visualizes aptitude to teaching act as catalyst. B.Ed course has its own importance and it's the pillar that helps and individuals to impart quality education by practice innovative teaching.

India being a developing country, the teachers have the great responsibility of making the students competent enough to stand with their counterparts in the developed countries and to make the country economically independent [1]. To retain the enrolled masses in the classroom, to make real education possible, to increase the level of Teachers are the largest professional group engaged in human development activities. Teaching is the core profession and the key agent of change in today's knowledge society. Issue of teacher quality, training and continuous professional development is vital to the improvement of not only our education system but also in achieving the goal of

education for all. Thus, the role of teachers is vital to any educational institution and their competencies greatly influence the entire system of education (Rahman, 2017) [2]. As Ahmed (2013) highlighted to mean a professional teacher means to have all types of skills to develop the students to their utmost. A teacher cannot be said as professional in his work unless he is able to use their skills in his professional service [3].

Teacher's Technological, Pedagogical and Content Knowledge (TPACK) underlying truly effective and highly skilled teaching with technology. TPACK is different from knowledge of its individual component concepts and their intersections. It arises instead from multiple intersections among content, pedagogical, technological and contextual knowledge. TPACK is the basis of effective teaching with technology. Perhaps the concepts of TPACK are comparatively new. Furthermore, the nature and amount of TPACK usage are different in India as used in other countries. Hence in view of the above issues and genuine concern in this regard necessitates the investigator to conduct a study of this nature [4, 5]

### **Technological Pedagogical Content Knowledge (TPACK)**

TPACK is a combination of Technology, Pedagogy and Content which is required as a whole for the teachers to

teach a particular content using different new technologies and methods and strategies. TPACK should help the pre-service teacher trainees to develop their confidence and practice in all the three components i.e., Technology, Pedagogy and Content so that they can teach in a more developed and effective way. It helps in developing the creativity of the pre-service teacher trainees to teach in a more innovative way. Technological, Pedagogical and Content Knowledge (TPACK) is the knowledge of the use of technology in various subjects and practicing teaching methods. This knowledge makes the learning of the subject for the student easier with appropriate pedagogy and technology.

TPACK is the base for effective teaching with technology which includes an understanding of how to present concepts with technology, how to use pedagogical techniques that use technology in teaching the content indirectly, the knowledge of the concepts which make learning easier or harder, the knowledge of how the technology will be helpful for learning, the knowledge of the students' previous knowledge and the knowledge of epistemological theories, the knowledge of how to use technology in building new information into existing knowledge and which also includes the development of new epistemologies, or strengthening the old ones.

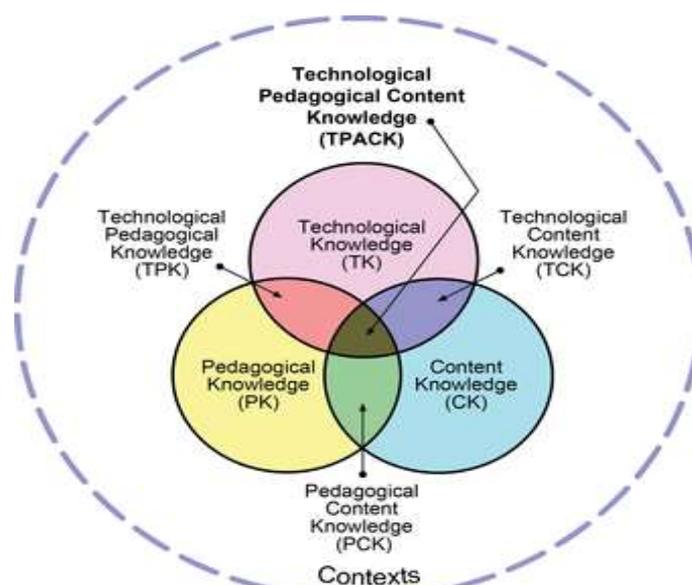


Diagram 1

Source: Koehler, Mishra & Kereluik *et al* (2014).tpack.org

Technology, pedagogy and content knowledge is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones [6, 7].

The TPACK framework is made up of seven different knowledge components. There are the three core components of knowledge (Content, Pedagogy, and Technology), three dyadic components of knowledge (Pedagogical, Content, Technological Content, Technological Pedagogical) and one overarching triad (Technological, Pedagogical, content Knowledge). This scale gives more prominence to the use of technology in education in the form of Technological Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) compared to Pedagogical

and Content Knowledge. TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies, using knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face. The NCF (2005), and XII five year plans (2011), emphasized to provide connectivity, valuable content and low cost computing devices to all the institutions of higher learning in the country.

The lack of awareness of TPACK knowledge leads to problems in using technology in classroom. TPACK helps in knowing about the teachers' abilities and needs and also about their potentials and capabilities. TPACK will also help the pre-service teacher trainees to further improve their training on how to use technology in their teaching in classroom situation. It helps in mapping the knowledge, abilities and needs of the pre-service teacher trainees. Pedagogical Content Knowledge is also known as 'Craft Knowledge'

There has been an increased attention towards the problem of teacher education throughout the country. But there is no much appreciable progress in Tezpur, Assam. Proper use of technology in teaching should be taught to the pre-service teacher trainees in order to prepare better teachers for the future generation.

---

---

## LITERATURE REVIEW

Some of the researchers have conducted studies on Technological Pedagogical Content Knowledge. Some of their findings are as follows:

Cubeles (2018) confirmed the usefulness of the model and revealed the significant differences regarding the previous academic experience of the teacher. The investigation contributes to the studies that aim to foster the effective integration of technology in teaching and learning [8].

Wang (2018) found that the pre-service teacher was able to successfully integrate technology in her teaching during her practicum experience that demonstrated characteristics from all seven TPACK domains [9]. Angeli (2013) showed that the technology mapping was effective in developing TPCK competencies; however, development of TPCK competencies was directly related to the complexity of the design task [10]. Chai & Tsai (2011) found that pedagogical knowledge had a direct impact on TPACK at the beginning of the course. The comparison between the pre and the post-course models also revealed that the pre service teachers' perceived relations between content knowledge and TPACK changes from insignificant to significant [11]. Polly (2011) study displayed evidence of TPACK, their enacted pedagogies did not completely align to the pedagogies emphasized during

professional development. Implications and suggestions for supporting and researching teachers' development of TPACK are also shared. And, teachers' use of technology only developed students' higher-order thinking skills and conceptual understanding in limited ways. Implications for future professional development projects and the TPACK model are also discussed [12]. Angeli (2009) found that the ICT-TPCK competency significantly showed positive impact and improved over the course of a semester [13].

## OBJECTIVES OF THE STUDY

The major objectives of the present study are as follows:

- To study the perception of pre-service teachers towards technological Pedagogical Content Knowledge and its dimensions.
- To study the significant differences in the perception of pre-service teachers towards Technological Pedagogical Content Knowledge in relation to gender, locality, type of management, nature of subject taken (subject), their highest qualification, and completion of internship process.

## HYPOTHESES OF THE STUDY

The hypotheses of this study are as follows:

- There is no any significant difference in the perception on TPACK components between male and female pre-service teachers.

- There is no significant difference in the perception on TPACK components between urban and rural pre-service teachers.
- There is no significant difference in the perception on TPACK components between pre-service teachers studying B.Ed.in Central and State institutions.
- There is no significant difference in the perception on TPACK components between arts and science stream pre-service teachers.
- There is no significant difference in the perception on TPACK components between pre-service teachers pursuing undergraduate and postgraduate courses.
- There is no significant difference in the perception on TPACK components between pre-service teachers completed internship and not completed internship training.

### **METHODOLOGY OF THE STUDY**

In the present study normative survey method was used for collecting data.

### **POPULATION AND SAMPLE**

In the present study, the population was all the pre-service teachers of the two government B.Ed institutes at Sonitpur district of Assam. A sample of 170 pre-service teachers was selected as samples from these two government B.Ed institutes. The study is restricted to 170 B.Ed. pre-service teachers of Sonitpur district of

Assam for the academic session of 2018-2019.

### **TOOLS**

The tools used in the study are as follows:

- Teachers' Technological Pedagogical and Content Knowledge Scale (TTPACKS-SHSL) by Prof. Hemant Lata Sharma and Ms. Leena Sharma.
- Personal data sheet constructed by the investigator.

### **Description of the Tool**

The used TPACK Scale is designed to measure Technological, Pedagogical and Content Knowledge (TPACK) among teachers' in Indian perspective. The test contains 55 items. This test is divided into seven areas Technological Knowledge, Pedagogical Knowledge, Content Knowledge, Technological Pedagogical Knowledge, Technological Content Knowledge, Pedagogical Content Knowledge, and Technological Pedagogical Content Knowledge. The Scale is a Likert type five alternative answer type scale, viz., Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree.

### **DATA ANALYSIS AND INTERPRETATION**

In the present study the researcher used both descriptive and differential statistical techniques to analyze the data, In addition to that t-test was employed to test the hypotheses, where the abbreviations of

study's variables Technological Pedagogical Content Knowledge: TPACK is in the following section.

The above **Table 1**, indicates that 51 (30%) pre-service teachers showed most Favourable Perception level towards Technological Pedagogical Content Knowledge, and 103 (61 %) pre-service teachers showed above average Favourable Perception level towards Technological Pedagogical Content Knowledge, and only 16 (9%) pre-service teachers showed above average Favourable Perception level towards Technological Pedagogical Content Knowledge. **Table 2** shows the Demographic variable wise perception level of Pre-Service Teachers towards TPACK

It is inferred from **Table 2** that based on gender it is inferred that from out of 50 male pre-service teachers 22 of them are having most favourable, 24 are above average, and 4 are average favourable perception towards TPACK. It is also interpreted that out of 120 female pre-service teachers 29 of them having a most favourable, 79 having above average, and 12 are having average favourable perception towards TPACK.

Based on locality, it is inferred that from out of 70 pre-service teachers from out of urban preservice teachers, 16 of them are having most favourable, 46 are having above average, and 8 are having average

favourable perception towards TPACK. It is also interpreted that from out of 100 pre-service teachers from rural 35 are having most favourable, 57 having a above average, and 8 are having average favourable perception towards TPACK.

Based on stream of study, it is inferred that from out of 120 arts samples, 30 are having a most favourable, 86 are having above average, and 4 are having average favourable perception towards TPACK. It is also interpreted that from 50 science pre-service teachers, 21 are having a most favourable, 17 are having above average, and 12 are average favourable perception towards TPACK.

Based on their qualification, it is inferred that from out of 60 undergraduate samples, 19 are having a most favourable, 36 are having a above average, and 5 are having average favourable perception towards TPACK. It is also interpreted that from out of 110 pre-service teachers whose highest qualification is postgraduate, 32 are having a most favourable, 67 are having a above average, and 11 are average favourable perception towards TPACK.

Based on the type of management, out of 85 preservice teachers doing B.Ed in Central institutes 27 are having a most favourable, 50 are having an above average, and 8 are having average favourable perception towards TPACK. It is also interpreted that from out of 85 pre-

service teachers doing B.Ed. in state institutes, 24 are having a most favourable, 53 are above average, and 8(4%) are having a average favourable.

Based on the completion of internship training, out of 56 who have completed the internship training, 12 are having a most favourable, 39 are having an above average, and 5 are having an average favourable perception towards TPACK. It is also interpreted that out of 114 who has not completed internship training, 39 are having a most favourable, 64 are having an above average, and 11 are average favourable perception towards TPACK.

**Hypothesis 1: There is no significant difference in the perception on TPACK components between the male and female pre-service teachers.**

From **Table 3**, male have the mean score of 226.92 with standard deviation 20.01. Female have the mean score of 219.83 with standard deviation 23.97. The mean difference is 7.09 between mean score of Technological, Pedagogical and Content Knowledge of male and female pre-service teachers. The obtained t-value 1.839 and level of significance is 0.038, which is less than the table value significant at 0.05 levels with degrees of freedom 168.

**Hypothesis 2: There is no significant difference in the perception on TPACK components between the Urban and Rural pre-service teachers.**

From **Table 4**, urban students have the mean score of 219.49 with standard deviation 27.35. Rural students have the mean score of 223.62 with standard deviation 19.44. The mean difference is 4.13 between mean score of Technological, Pedagogical and Content Knowledge of urban and rural pre-service teachers. The obtained t-value 1.152 and level of significance is 0.251, which is greater than the table value significant at 0.05 levels with degrees of freedom 168.

**Hypothesis 3: There is no significant difference in the perception on TPACK components between pre-service teachers studying B.Ed. in central and state institutions.**

From **Table 5**, Pre-service teachers studying B.Ed.in Central institutions have the mean score of 222.18 with standard deviation 18.74. Pre-service Teachers studying in state institutes have the mean score of 221.66 with the standard deviation 26.78. The mean difference is 0.52 between mean score of Technological, Pedagogical and Content Knowledge of pre-service teachers studying B.Ed. in Central and State institutions found to be significant at 0.05 levels of significance. The obtained t-value 0.146 and level of significance is 0.884, which is greater than the table value significant at 0.05 levels with degrees of freedom 168.

**Hypothesis 4: There is no significant difference in the perception on TPACK Components between Arts and science pre-service teachers.**

From **Table 6**, pre-service teachers pursuing arts have the mean score of 220.17 with standard deviation 22.82. Science pre-service teachers have the mean score of 226.93 with standard deviation 23.21. The mean difference is 6.76 between mean score of Technological, Pedagogical and Content Knowledge of Arts and Science pre-service teachers is found to be significant at 0.05 levels of significance. The obtained t-value 1.685 and level of significance is 0.441, which is greater than the table value significant at 0.05 levels with degrees of freedom 168.

**Hypothesis 5: There is no significant difference in the perception on TPACK components between pre-service teachers completed undergraduate and postgraduate courses.**

From **Table 7**, the pre-service teachers completed undergraduate courses have the mean score of 219.17 with standard deviation 26.9. Post Graduate pre-service teachers have the mean score of 223.42 with standard deviation 20.62. The mean

difference is 4.25 between mean score of Technological, Pedagogical and Content Knowledge of Undergraduate and Postgraduate pre-service teachers is found to be significant at 0.05 levels of significance. The obtained t-value 1.150 and level of significance is 0.252, which is greater than value significant at 0.05 levels with degrees of freedom 168.

**Hypothesis 6: There is no any significant difference in the perception on TPACK components between having internship process and not having internship process in pre-service teachers.**

From **Table 8**, having internship process the mean score of 224.87 with standard deviation of 23.64. Not having internship process have the mean score of 217.70 with standard deviation 21.63. The mean difference is 7.17 between mean score of Technological, Pedagogical and Content Knowledge of pre-service teachers having internship process and not having internship process is found to be significant at 0.05 levels of significance. The obtained t-value 2.014 and level of significance is 0.046, which is less than the value significant at 0.05 levels degrees of freedom 168.

**Table 1: Showing Perception level of Pre-Service teachers towards TPACK**

| Perception level towards TPACK | N   | Percentage | Mean   | S.D   |
|--------------------------------|-----|------------|--------|-------|
| Most Favorable                 | 51  | 30         | 243.12 | 10.55 |
| Above average Favorable        | 103 | 61         | 218.34 | 9.88  |
| Average Favorable              | 16  | 9          | 192.69 | 13.04 |

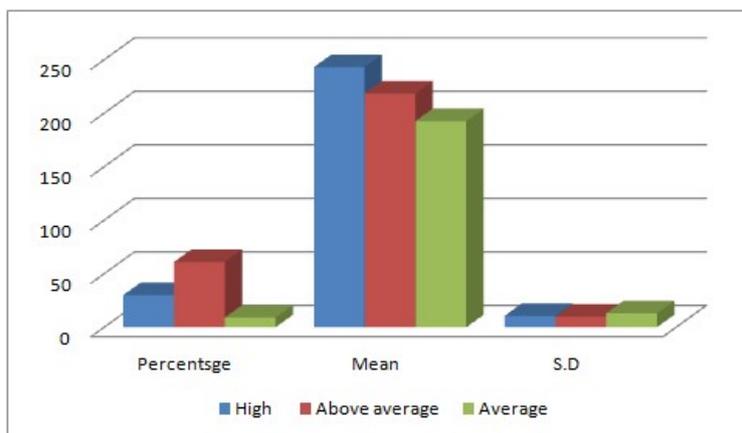


Figure 1: Bar chart showing Perception level of Pre-service teachers towards TPACK

**Table 2: Showing the Demographic variable wise Perception level of Pre-Service Teachers towards TPACK**

| Demographic Variables | Sub variables | Perception level of pre-service teachers |                         |                   |       |
|-----------------------|---------------|--|-------------------------|-------------------|-------|
|                       |               | Most Favorable                           | Above average Favorable | Average Favorable | Total |
| Gender                | Male          | 22                                       | 24                      | 4                 | 50    |
|                       | Female        | 29                                       | 79                      | 12                | 120   |
| Locality              | Urban         | 16                                       | 46                      | 8                 | 70    |
|                       | Rural         | 35                                       | 57                      | 8                 | 100   |
| Stream of study       | Arts          | 30                                       | 86                      | 13                | 120   |
|                       | Science       | 21                                       | 17                      | 12                | 50    |
| Highest Qualification | UG            | 19                                       | 36                      | 5                 | 60    |
|                       | PG            | 32                                       | 67                      | 11                | 110   |
| Type of Management    | Central       | 27                                       | 50                      | 8                 | 85    |
|                       | State         | 24                                       | 53                      | 8                 | 85    |
| Internship Process    | Completed     | 12                                       | 39                      | 5                 | 100   |
|                       | Not completed | 39                                       | 64                      | 11                | 70    |

Table 3: Showing significant difference between the male and female pre-service teachers towards TPACK

| Test Variable                               | Gender | N   | Mean   | S.D.  | t-value | df  | Sig.(2 tailed)      |
|---|--------|-----|--------|-------|---------|-----|---------------------|
| Technological Pedagogical Content Knowledge | Male   | 50  | 226.92 | 20.01 | 1.839   | 168 | 0.038<br>(p < 0.05) |
|   | Female | 120 | 219.83 | 23.97 |         |     |                     |

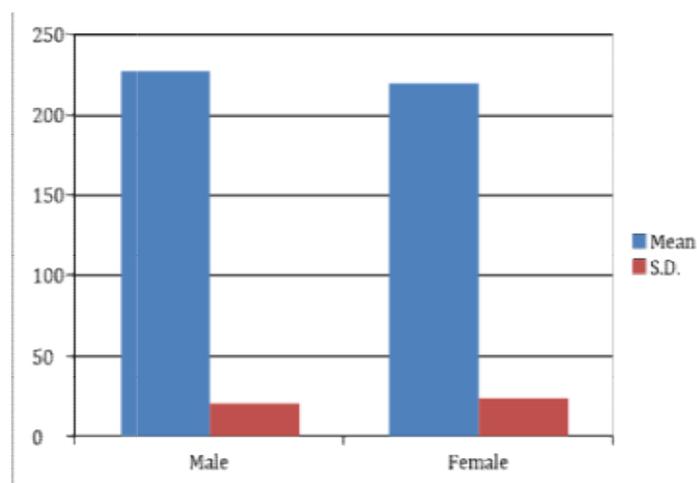


Figure 2: Showing the gender wise difference in TPACK in pre-service teachers

Table 4: Showing the significance difference between the Urban and Rural pre-service teachers

| Test Variable                                    | Locality | N   | Mean   | S.D.  | t-value | df  | Sig.(2 tailed)    |
|--|----------|-----|--------|-------|---------|-----|-------------------|
| Technological, Pedagogical and Content Knowledge | Urban    | 70  | 219.49 | 27.35 | 1.152   | 168 | 0.251<br>(p>0.05) |
|  | Rural    | 100 | 223.62 | 19.44 |         |     |                   |

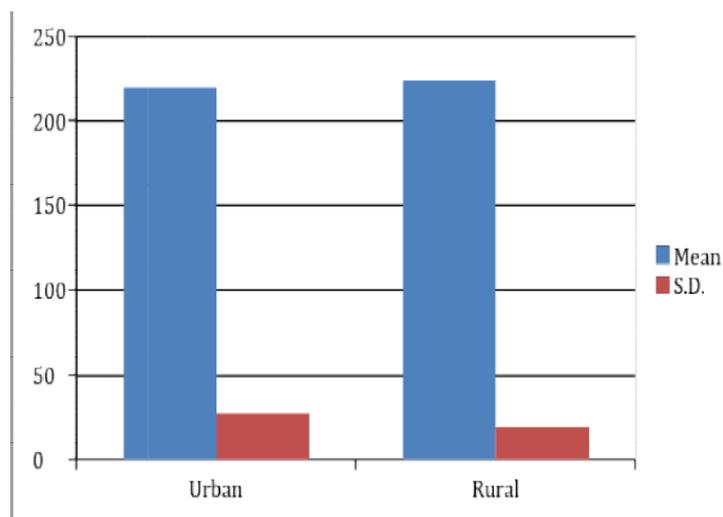


Figure 3: Showing the locality wise difference in TPACK in pre-service teachers

Table 5: Showing the significant difference between Central and State pre-service teachers

| Test Variable                                    | Type management | N  | Mean   | S.D.  | t-value | Df  | Sig.(2 tailed) |
|--|-----------------|----|--------|-------|---------|-----|----------------|
| Technological, Pedagogical and Content Knowledge | Central         | 85 | 222.18 | 18.74 | 0.146   | 168 | 0.884 (p>0.05) |
|  | State           | 85 | 221.66 | 26.78 |         |     |                |

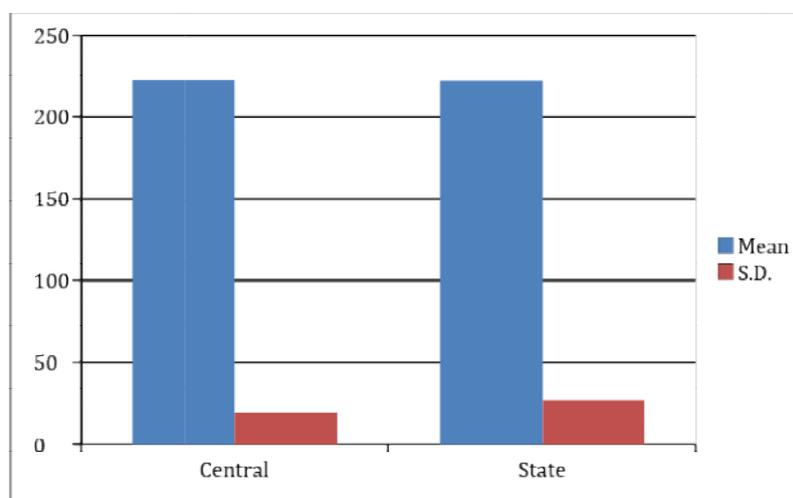


Figure 4: Showing the type of management wise difference in the TPACK in pre-service teachers studying B.Ed. in central and state institutions

Table 6: Showing the significance difference between Arts and Science pre-service teachers in TPACK

| Test Variable                                    | Nature of subject | N   | Mean   | S.D.  | t-value | df  | Sig.(2 tailed) |
|--|-------------------|-----|--------|-------|---------|-----|----------------|
| Technological, Pedagogical and Content Knowledge | Arts              | 120 | 220.17 | 22.82 | 1.685   | 168 | 0.44 (p>0.05)  |
|  | Science           | 50  | 226.93 | 23.21 |         |     |                |

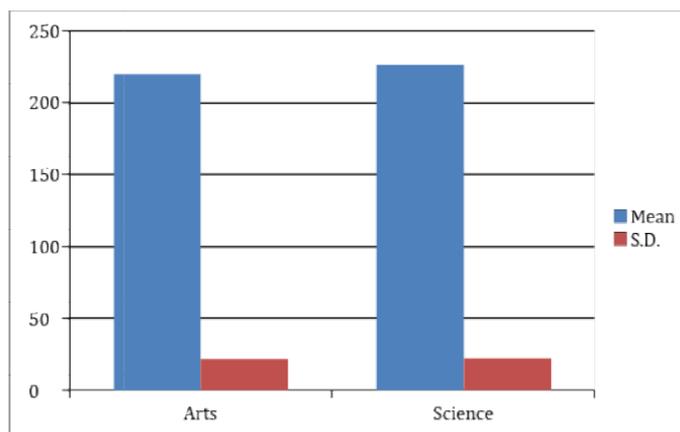


Figure 5: Showing the nature of subject (stream) wise difference in TPACK in pre-service teachers

Table 7: Showing the significance difference between the pre-service teachers completed undergraduate and postgraduate courses in TPACK

| Test Variables                                   | Highest Qualification | N   | Mean   | S.D.  | t-value | df  | Sig.(2 tailed) |
|--|-----------------------|-----|--------|-------|---------|-----|----------------|
| Technological, Pedagogical and Content Knowledge | Undergraduate         | 60  | 219.17 | 26.9  | 1.150   | 168 | 0.252 (p>0.05) |
|  | Post Graduate         | 110 | 223.42 | 20.62 |         |     |                |

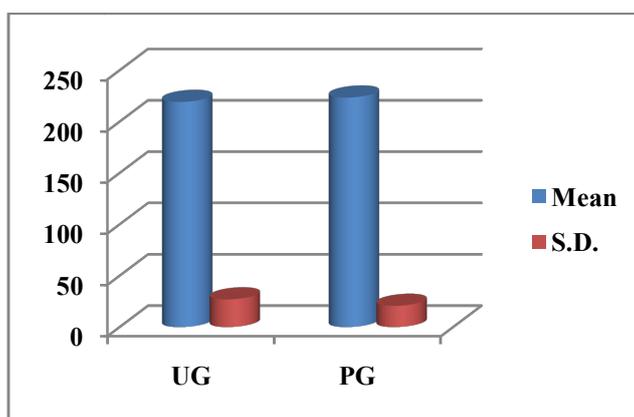


Figure 6: Showing the qualification wise difference in TPACK

Table 8: Showing the significance difference between the Internship Process in TPACK

| Test Variable                                    | Internship Process            | N   | Mean   | S.D.  | t-value | df  | Sig. (2 tailed) |
|--|-------------------------------|-----|--------|-------|---------|-----|-----------------|
| Technological, Pedagogical and Content Knowledge | Having internship process     | 100 | 224.87 | 23.64 | 2.014   | 168 | 0.046 (p<0.05)  |
|  | Not having internship process | 70  | 217.70 | 21.63 |         |     |                 |

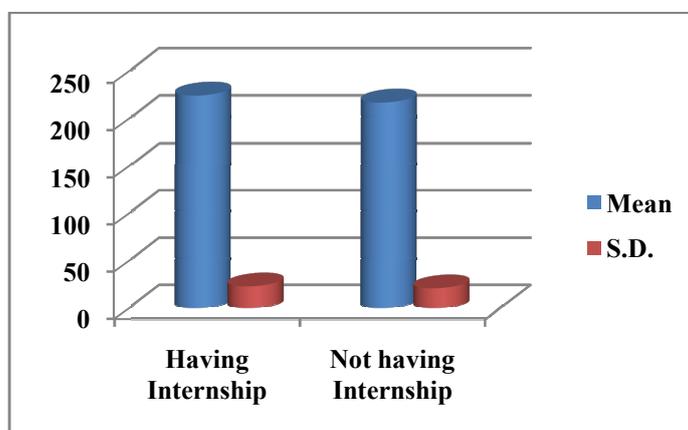


Figure 7: Showing the internship process wise difference in TPACK

---

---

## FINDINGD OF THE STUDY

The major findings of the study are as follows:

1. There is a significant difference between the male and female pre-service teachers in average scores of Technological, Pedagogical and Content Knowledge.
2. There is no significant difference between the urban and rural pre-service teachers in average scores of Technological, Pedagogical and Content Knowledge.
3. There is no significant difference between the Central and the State pre-service teachers for securing the average score of Technological, Pedagogical and Content Knowledge.
4. There is no significant difference between the Arts and Science pre-service teachers for securing the average score of Technological, Pedagogical and Content Knowledge.
5. There is no significant difference between the Undergraduate and the Postgraduate pre- service teachers for securing the average score of Technological, Pedagogical and Content Knowledge.
6. There is a significant difference between the pre-service teachers having internship process and not having internship process for securing the

average score of Technological, Pedagogical and Content Knowledge.

## CONCLUSION

After the study, it can be concluded that the Male students have a little better perception on Technology, Pedagogy and Content Knowledge than the Female students. The students from urban place have a little more knowledge about Technology, Pedagogy and Content than the students from rural place. The trainees who belongs to the State institutions have little more Technological, Pedagogical and Content Knowledge than the trainees who belongs to the Central institutions. The trainees whose nature of subjects is Science have a little more knowledge on Technology, Pedagogy and Content than the trainees whose nature of subjects is Arts. The Postgraduate students have a little more Technological, Pedagogical and Content Knowledge than the Undergraduate students. The trainees who are having internship have a little more Technological, Pedagogical and Content Knowledge than the trainees who are not having internship.

## SUGGESTIONS

Some of the further suggestions are as follows:

1. The pre-service teacher trainees should be made aware of when to use which kind of technology to make the student understand the content in a better way.

2. Technological, Pedagogical and Content Knowledge helps in understanding how and when which technology is to be used.
3. Proper pedagogical knowledge is also acquired as it helps the pre-service teacher trainee to understand about the pedagogical knowledge.
4. Teaching which takes place using technology is done most effectively.
5. Everyone uses technology in their daily life and TPACK helps in developing the practical skills more and makes the work easier.

## REFERENCES

- [1] Akarat T, Designing TPACK-based course for preparing student teachers to teach science with technological pedagogical content knowledge. *Kasetsart Journal of Social Sciences*, 2018: 1-7.
- [2] Rahman MA, Aeni N, Jabu B, English oral communication apprehension in students of Indonesian Maritime. *International Journal of English Linguistics*, 7 (4); 2017: 158-167.
- [3] Ahmed K, Teacher-Centered Versus Learner-Centered Teaching Style. *Journal of Global Business Management*, 9(1); 2013: 22-34.
- [4] Chai CS, Koh JHL, Tsai CC, Facilitating Preservice Teacher's Development of Technological, Pedagogical, and Content Knowledge (TPACK). *Educational Technology & Society*, 13(4); 2010: 63-73.
- [5] Graham CR, Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education*, 57(3); 2011: 1953-1960.
- [6] Koehler M J, Mishra P, What happens when teachers design educational technology? The development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research*, 32(2); 2005: 131-152.
- [7] So HJ, Kim B, Learning about problem based learning: student teachers integrating technology, pedagogy and content knowledge. *Australasian Journal of Educational Technology*, 25(1); 2009: 101-116.
- [8] Cubeles A, Riu D, The effective integration of ICTs in Universities: the role of knowledge and academic experience of professors. *Technology, Pedagogy and Education*, 27(1); 2018: 339-349.
- [9] Wang W, Pre-service Teachers' TPACK Development: A Review of Literature. *Journal of Digital Learning in Teacher Education*, 32(4); 2018: 234-258.

- [10] Angeli C, Valanides N, Technology Mapping: An Approach for Developing Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research*, 48(2), 2013: 199-221.
- [11] Chai CS, Tsai C, Modeling Primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, 57(1); 2011: 1184-1193.
- [12] Polly D, Developing Teachers' Technological, Pedagogical and Content Knowledge (TPACK) through Mathematics Professional Development. *International Journal for Technology in Mathematics Education*, 18(2); 2011: 83-96.
- [13] Angeli C, Valanides N, Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education*, 52(1); 2009: 154-168.