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AN INVESTIGATION ON MATHEMATICS TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) IN SECONDARY SCHOOL SETTING IN ASSAM

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Abstract— The theoretical structure of Technological Pedagogical Content Knowledge (TPACK) plays an increasingly important role in the restructuring of teaching learning process both in our country and in the world. The TPACK system tries to help the advancement of better strategies for finding and portraying how technology related proficient learning is actualized and manifested practically (Matthew et al., 2013). As research in TPACK becomes more empirical, it becomes more important that researchers scrutinize the measurement properties of TPACK instruments. The critical issue of "does my instrument accurately capture my participants' levels of understanding in TPACK?" needs to be addressed first as it is essential for good research (Kelly, 2010; Koehler et al., 2011). Researchers who develop TPACK survey instruments, however, have devoted attention to the reliability and validity properties of TPACK measurement. Specifically, TPACK survey research has allowed researchers to further address the issues like – internal consistency, test–retest reliability, and discriminant and convergent validity about the measurement of TPACK. In this research, the examination concentrated on Mathematics Teachers' Technological Pedagogical Content Knowledge (TPACK) for utilizing ICT in educating and learning successfully in secondary schools. This examination was completed with 45 mathematics educators serving in 38 secondary schools situated in a hilly region of Assam. The sample survey method was adopted for the present investigation. A research instrument was developed to measure Mathematics Teachers' Technological Pedagogical Content Knowledge (TPACK) for utilizing technology in teaching-learning process. Gathered information was examined through various statistical tools. The information was investigated dependent on 7 distinctive learning premise characterized in TPACK structure.

Keywords— TPACK, Teaching Learning process, ICT, Secondary Schools, Professional development, Teacher knowledge.

1. INTRODUCTION

The competences that the teacher possesses to make effective the integration of the Information and Communication Technologies (ICT) in education should be a subject to be addressed necessarily at any educational level, since it is an aspect to which we cannot give the back. We live in the information society and in this context technology is present, and it will be even more so in future generations. That is why the fusion of ICT in the educational field must be a reality.

In this context, the teacher plays a fundamental role in teaching-learning processes mediated by ICT and, for this, teachers must acquire certain knowledge. A model that clearly describes what such knowledge, is the TPACK model articulated by Mishra and Koehler (2006). TPACK stands for Technological Pedagogical Content Knowledge (Technological, Pedagogical and Disciplinary Knowledge) and, with this; we want to capture a reference around the typology and nature of the teacher's digital competences. The TPACK model is based, in part, on the so-called "Didactic Content Knowledge", originally formulated by Shulman (1987), which manifested the design that teachers must have knowledge about content and pedagogy. Based on this idea, Mishra and Koehler (2006) formulated their TPACK model, which aims to define the assorted types of information that teachers need to have in order to integrate ICT effectively in the classroom. The TPACK model defines precisely the consideration of instrumental, disciplinary and methodological knowledge in a context of ICT integration. In addition, knowledge is not considered independently, but as an interrelated set that affects the teacher in an integral way. Thus, seven types of knowledge are generated that must be addressed as such.

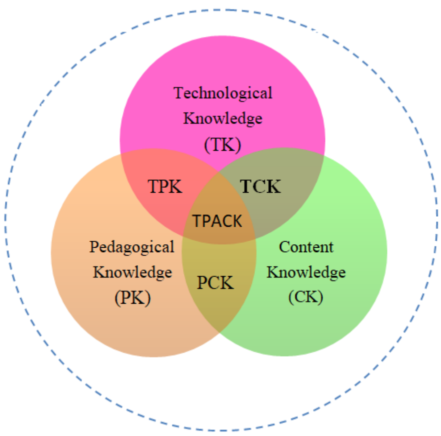

Figure 1: Framework of TPCK: (Mishra & Koehler, 2008)

2. COMPONENTS OF TPACK:

In the TPACK technology knowledge, didactic knowledge and content knowledge cross cut, convey, and affect each other to outline and teach not only a teacher's appreciation of substance, teaching technique, furthermore, technology, yet likewise blends of these three learning spaces.

Technology Knowledge (TK)
Technology Knowledge (T or TK) is knowledge about standard advances, for instance, books and chalk and writing board, and also further created trend setting technologies, for instance, the Internet and computerized video (Mishra and Koehler, 2008). This would incorporate the aptitudes required to work particular advances. By virtue of digital propels, this would join knowledge of working frameworks and digital gears, and furthermore the ability to use standard programming apparatus including web browsers, email tasks, and word-excel-processors. It consolidates essential finding out about presenting and updating equipments and programming, keeping up data accounts, and remaining leap forward about reliably developing advancements.

Pedagogy Knowledge (PK)
Pedagogy Knowledge (P or PK) is significant knowledge about the methodology and practices or procedures for educating and learning and how it fuses as a rule informative purposes, characteristics and focuses (Mishra and Koehler, 2008). This is a non-exclusive sort of knowledge that is locked in with all issues of students learning, classroom organization, practice plan progression and execution, and students' evaluation. It joins knowledge about frameworks or strategies to be used in the classroom; the nature of the planned intrigue gathering; and techniques for surveying learners understanding.

Content Knowledge (CK)
Content Knowledge (C or CK) is the knowledge about the genuine theme that will be found out or taught. It is the real knowledge that teachers have of what they should teach. The substance to be anchored moves essentially by age level and topic. Teachers must know and fathom the subjects they train, including learning of central assurances, thoughts, theories and approach inside a given field.

Pedagogical Content Knowledge (PCK)
In the TPACK system, there are three domains of knowledge delineated by the three equal sets by circular diagrams: Technology, Pedagogy, and Content. The intersection regions of these three domains are equally significant in this system. The main crossing point in the system is between pedagogy and content information, or "*Pedagogical Content Knowledge*" (PCK or PC) (Shulman, 1987).

Technology Content Knowledge (TCK)
Technological content knowledge (TCK or TC) alludes to learning about how technology might be utilized to give new better approaches for educating subject content (Niess, 2005). According to Mishra & Koehler (2008) TCK alludes to knowledge about the affordances and limitations of technology as an empowering influence of various instructing approaches.

Technological Pedagogical Knowledge (TPK)
TPK is the ability to comprehend how to apply technological tools to support teaching practice, supported by teaching and learning strategies. It concerns the didactic methods infused with digital innovations used to develop a specific activity, related to teaching process. It also implies knowing and ties according to the technological instrument in use, all stages of educating and learning processes, from the taking of the previous conceptions to the evaluation aspects, with a view to meaningful learning.

Technological Pedagogical and Content Knowledge (TPACK)
TPACK is the knowledge how to coordinate the specific contents of the subject using ICT to facilitate student learning.
In short, it refers to the knowledge required by teachers to infuse technology in their teaching in any disciplinary area.

The conceptual framework of P. Mishra and M. J. Koehler's "Technological Pedagogical and Content Knowledge" (TPACK) was initially presented with the acronym TPCK, but was later changed to TPACK to put stress on the concept of totality and integration between the constituent parts. The TPACK was proposed by Mishra & Koehler (2006), to guide professional teacher development regarding the use of digital technologies in the various educational contexts. It could be better understood from the studies of Niess et al. (2009), Mishra & Koehler (2006, 2008).

Niess (2005) also used the term TPACK, but viewed it as extended PCK, referring to technology-enhanced PCK. Niess (2015, p. 22) developed four different aspects that consist of teachers' TPACK, with five levels of development for each aspect: (1) an overarching conception of what it means to teach with technology, (2) knowledge of students' thinking and understanding of specific topics with technologies, (3) knowledge of curricular materials that incorporate technologies, and (4) knowledge of instructional strategies and representations for teaching subject matter with technologies. In her description of aspects and levels of teachers' TPACK, teachers' beliefs play an important role. Teachers develop their TPACK through "a constructive and iterative process" of confronting, reflecting on, and carefully revising their various experiences for teaching mathematics with appropriate technologies based on their beliefs and knowledge (Niess, 2015, p. 24). Therefore, teachers' beliefs and TPACK are closely related, and TPACK should be considered with beliefs.

It is important to note that all types of teacher knowledge, including TPACK, are influenced by contextual factors, such as culture, socioeconomic status, and school organizational structures (Harris & Hofer, 2011). While studying a teacher's TPACK trajectory, researchers should consider school philosophy and expectations, demographic characteristics of students and teachers. Moreover, there are other components of contextual factors need to be considered which are cognitive, experimental, physical, psychological, and social characteristics of students and teachers, and physical features of the classroom (Kelly, 2008).

3. OBJECTIVE OF THE STUDY:

Knowledge of technology, pedagogy and subject content is important for teachers in their attempt to effectively infuse technologies in the teaching of school Mathematics. The objectives of this study are to

i) Determine the level of technological pedagogical content knowledge (TPCK) among mathematics teachers teaching in secondary schools.

ii) Are techno-pedagogical Knowledge (TPACK) of mathematics teachers significantly different regarding

a) Gender (X_1)

b) The socioeconomic levels of the school they work in.(X_2)

c) Professional seniority.(X_3)

d) In Service training status.(X_4)

e) Professional satisfaction.(X_5)

iii) Explore the fusion of TPCK in their teaching practices in the classroom.

4. NULL HYPOTHESES:

On the basis of the above research questions, the accompanying void hypotheses were drafted:

H_1^0: There is no significant gender difference among secondary school mathematics teachers regarding TPACK

H_2^0: There is no noteworthy differences between secondary school mathematics teachers TPACK and socioeconomic levels of the school they work in.

H_3^0: There are no noteworthy variations between secondary school mathematics teachers' TPACK and their professional seniority.

H_4^0: There are no noteworthy variations between secondary school mathematics teachers'TPACK and their status of In Service training.

H_5^0: There are no noteworthy variations between secondary school mathematics teachers' TPACK and their professional satisfaction.

5. METHODOLOGY:

This study combines both quantitative and qualitative approaches in two phases. In the first phase, a survey method using a questionnaire was carried out among participated mathematics teachers.

Universe and Sample: The universe of the examination comprises of mathematics teachers working in secondary school in a hilly district of Assam. A group of 45 mathematics teachers teaching in secondary/higher secondary schools participated in the study. Regarding gender, 23 are male teachers and 22 are female mathematics teachers. Service lengths of teachers are divided into five subgroups; Schools' socioeconomic levels, teachers' job satisfaction are other independent variables each of which is subdivided into three factors (Table 1).

Research Instrument:

A research instrument was developed for the present study. The instrument was developed to access mathematics teachers' technological, pedagogical and content knowledge (TPACKM). There were two parts in TPACKM scale. Part-A was related to demographic information of the respondents and the part B-related to their TPACK in mathematics. The original text of the scales given by Riel & Becker (2000), Knezek & Christiansen (2004), Keller, Bonk & Hew (2005), Mishra & Koehler (2006), Schmidt et al. (2009) were studied before the preparation of the proposed measurement tool. The scale was prepared by focusing on the fields of mathematics. There are seven factors in the scale. In each factor, except TPACK, includes 5 items. The TPACK factor consists of 8 items. The items are five-point Likert-type, I strongly agree (5), I agree (4), I am undecided (3), I disagree (2), I strongly disagree (1). The data were collected by the researcher from the respondents.

Pilot Survey: A pilot survey was done to test the evenness of the instrument. For this purpose a set of 12 mathematics teachers were selected. RStudio programming package was applied for Cronbach Alfa (α) reliability test. α value was found as 0.897 which indicates that the items in the TPACKM are firmly identified with one another.

Data Analysis: Analysis of collected data is performed with the help of RStudio programming package (Version 1.1.463).

Table **1:**
Demographic Characteristics of the Participating Teachers

Variables	No of teachers		%
Gender (X_1)	Male	23	51.1
	Female	22	48.9
Socioeconomic Level (X_2)	Lower	10	22.2
	Middle	26	57.8
	Upper	9	20.0
Professional Seniority (X_3) (In Years)	0-5	5	11.1
	5 -10	9	20.0
	10-15	15	33.3
	15-20	13	28.9
	20 above	3	06.7
In-Service Training Status (X_4)	Yes	40	88.9
	No	05	11.1
Professional Satisfaction (X_5)	No	08	17.8
	Partially	15	33.3
	Yes	22	48.9

Table 2: Weights

Level	Score
Strongly Disagree (SD)	1
Disagree (D)	2
Neutral (N)	3
Agree (A)	4
Strongly Agree (SA)	5

Table 3: Item descriptions and codes of TPACKM

Factors	Items	Item Description
1.Pedagogical Knowledge (PK)	1.PK1	I can change the way of teaching depending on what my students understand.
	2.PK2	I can use a wide range of teaching approaches in the classroom.
	3.PK3	I can evaluate students' learning in many different ways.
	4.PK4	I know how to organize and maintain class management.
	5.PK5	I know the general conceptual understanding of students and misconceptions.
2.Mathematics Content Knowledge (MCK)	6.MCK1	I have enough knowledge of mathematics
	7.MCK2	I can relate mathematics to real life situation.
	8.MCK3	I know basic topics in mathematics for a specific class
	9.MCK4	I can prepare topic materials myself for mathematics class
	10.MCK5	I am aware of recent developments and applications in my mathematics
3.Technological Knowledge (TK)	11.TK1	I know how to solve the technological problems I encounter.
	12.TK2	I can learn technology easily.
	13.TK3	I can adapt to important new technologies.
	14.TK4	I have sufficient technical skills about the technology I should use.
	15.TK5	I spend a lot of time with technology.
4.Pedagogical Mathematics Content Knowledge (PMCK)	16.PMCK1	I can choose effective teaching approaches that guide students to learn and think about mathematics.
	17.PMCK2	I can prepare goals stated teaching plan and apply in my mathematics class
	18.PMCK3	I try to eliminating individual differences in mathematics class
	19.PMCK4	I have various strategies and ways to better understand mathematics.
	20.PMCK5	I can use a wide range of teaching approaches in the mathematics classroom.
5.Technology Mathematics Content Knowledge (TMCK)	21.TMCK1	I am confident in using technology to support my knowledge in mathematics.
	22.TMCK2	I can use technology to answer students' questions and can give meaningful explanations
	23.TMCK3	I can confidently use web-based tools to support my knowledge of mathematics.
	24.TMCK4	I can confidently use web-based tools to answer students' questions on all mathematics topics.
	25.TMCK5	I can confidently select the necessary technologies to enrich the content of mathematics course.

6.Technological Pedagogical Knowledge (TPK)	26.TPK1	I can choose technology that can improve the mathematics teaching approaches.
	27.TPK2	I can choose technology that can improve student learning in learning mathematics.
	28.TPK3	I can adjust the use of technology that I have learned with different teaching activities.
	29.TPK4	I can think more deeply about how technology can influence the teaching approach that I use in the classroom.
	30.TPK5	I think critically about how to use technology in teaching in my class.
7. Technological Pedagogical Mathematics Content Knowledge (TPACKM)	31.TPCKM1	I can teach by combining mathematics, technology and teaching approaches appropriately.
	32.TPCKM2	I can select the necessary technologies to teach and enrich the content of a mathematics course
	33.TPCKM3	I can use strategies that combine subject content knowledge, technology and teaching approaches
	34.TPCKM4	I can direct and assists my colleagues to use technology that is in accordance with teaching methods and contents.
	35.TPCKM5	I can choose the right technology to use in class so that it can improve students' mathematics skills.
	36.TPCKM6	I can choose the technologies that will make my teaching approaches more effective.
	37.TPCKM7	I can use teaching material that combines mathematics skills, technology, and teaching approaches.
	38.TPCKM8	I can use strategies that combine content knowledge, technology and teaching approaches

6. RESULTS AND INTERPRETATION:

22.2% of 45 mathematics teachers participating in the study were in a lower socioeconomic school where they work, 57.8% of them work in a middle socioeconomic school, and 20.0% of them work in upper socioeconomic schools. When the distribution by gender is examined, it is seen that 51.1% is female and 48.9% is male. At the point when the distribution of the educators as indicated by the position of the instructors is analyzed 11.1% of instructors is between 0-5 years, 20.0% is between 5-10 years, 33.3% is between 10-15 years, 28.9% is 15-20 years and 6.7% teachers' work experience is higher than 20 years. When in-service training status of the teachers who took an interest in the investigation was examined, 88.9% of them were in-service and 11.1% of them did not receive in-service training. When teachers' professional satisfaction was examined, 48.9% were satisfied with their profession, 33.3% were partially gratified and 17.8% are not satisfied with their profession.

The first null hypothesis of the study is to establish no notable gender difference among secondary school mathematics teachers TPACK. For this purpose, one way ANOVA for educators' attitudes regarding TPACK and gender variables is ran in RStudio programming package (Table 4). Significance value is obtained as $1.3e^{-12}$ which is significant in 0.001 level.

Table 4.Teachers' TPACK and Gender Variables ANOVA Results

One Way ANOVA	Df	Sum sq	Mean Sq	F value	Sig.
Gender$TPACK	1	40.68	40.68	62.44	(0.0000) $=1.32e^{-12}$ ***
Residuals	43	80.12	0.65		
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Hence, the null hypothesis $\mathbf{H_1^0}$ is rejected, i. e. there exists a significant gender difference regarding mathematics teachers' TPACK in school mathematics education.

Socioeconomic Level of the school in which the teacher works is an independent variable of the study. The significance level of one way ANOVA test regarding socioeconomic level variable and teachers' TPACK is found as $3.6e^{-05}$ which is equivalent to 0.000036< 0.001. This shows that socioeconomic level of the school is critically affiliated to teachers' TPACK, and consequently, $\mathbf{H_2^0}$ is rejected (Table 5).

Table 5: Teachers' TPACK and Socioeconomic Level Variables ANOVA Results.

One Way ANOVA	Df	Sum sq	Mean Sq	F value	Sig.
SEL $TPACK	1	8.43	8.428	18.39	(0.000036) $= 3.6e^{-05}$ ***
Residuals	43	56.37	0.458		
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Table 6 depicts the one way ANOVA outcomes of teachers' TPACK and teachers' service seniority. Significance value is 0.00605(< 0.01), which indicates that mathematics teachers' service seniority is notably affiliated to teachers' attitudes to ICT fusion. Hence, $\mathbf{H_3^0}$ is rejected.

Table 6: Teachers' TPACK and Service Seniority Variables ANOVA Results

One Way ANOVA	df	Sum sq	Mean Sq	F value	Sig.
Seniority $ TPACK	1	11.46	11.458	7.804	0.00605 **
Residuals	43	180.59	1.468		
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

One way ANOVA result of teachers' TPACK and in service training is reflected in the table 7. As significance value is 0.356 > 0.05, $\mathbf{H_4^0}$ is accepted.

Table 7: Teachers' TPACK and In Service Training Variables ANOVA Results

One Way ANOVA	df	Sum sq	Mean Sq	F value	Sig.
Training $ TPACK	1	0.081	0.08062	0.857	0.356
Residuals	43	11.567	0.09404		

Professional satisfaction is a vital variable of effective and successful teaching learning process. In this study, researchers aim to find out an affiliation between teachers' TPACK and mathematics teachers' job satisfaction. One way ANOVA test result is shown in the Table 8. Significance value is evaluated as 0.00416 which is smaller than 0.01 and this establishes a significant association between the variables. Hence, hypothesis $\mathbf{H_5^0}$ is rejected.

Table 8: Teachers' TPACK and Job Satisfaction Variables ANOVA Results

One Way ANOVA	df	Sum sq	Mean Sq	F value	Sig.
Satisfaction $TPACK	1	5.41	5.409	8.53	0.00416 **
Residuals	43	78.00	0.634		
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

In this investigation, the aim of the researcher is to find the level of association of mathematics teachers' TPACK in school teaching process. Result shows that the TPACK of mathematics teaching teachers' towards ICT fusion in mathematics class is moderate positive. Regarding gender, socioeconomic level of schools, teachers' professional seniority and job satisfaction, TPACK of teachers in mathematics teaching is notably associated. Teachers' in service training has no critical effect on the building of teachers' TPACK in mathematics teaching process.

The following recommendations may be included here:

This study was conducted for mathematics teachers. Therefore, further research may be carried on the level of TPACK in teaching process regarding teachers teaching subjects other than mathematics.

Mathematics teachers' TPACK in their classes are evaluated based on five independent variables viz. gender, socioeconomic level of the educational institution where they work, professional seniority, professional satisfaction and status of in service trainings. Further researches may be thought by taking more independent variables such as age, self confidence, satisfaction in working environment etc.

This research is limited to secondary school teachers only. Therefore, similar studies may be attempted in undergraduate and graduate level.

The authority should provide more technology effective training to teachers in general and mathematics teachers in particular to create positive attitude towards the fusion of ICT in teaching-learning process so that teachers can acquire more knowledge on TPACK.

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