Examining TPACKC Levels for Effective Mathematical Communication among in-Service Teachers

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Publication Date: 2025/02/11

Abstract: Innovation in pedagogical studies have necessitate a paradigm shift from Technological Pedagogical Content Knowledge (TPACK) to Technological Pedagogical Content Knowledge and Communication skills (TPACKC). Communication is vital for effective teaching and learning of Mathematics. Students learn better when they can decipher the mathematical ideas and content delivered by their teacher. It is on this premise that this study was carried out to examine the levels of Technological Pedagogical Content Knowledge and Communication skills (TPACKC) among in-service teachers in Lagos State, Nigeria. The study adopted a descriptive survey research type. The sample size for this study comprised 95 in-service teachers from 64 junior secondary schools in two educational districts in Lagos State, Nigeria. This study was guided by four research questions. Data was collected in this study by the use of four research instruments that were duly validated. They are Mathematics Teachers Technological Knowledge (MATETEK; r = 0.75) 7-item questionnaire; Mathematics Teachers Pedagogical Knowledge (MATEPEK; r = 0.80) 11-item questionnaire; Mathematics Teachers Content Knowledge (MATECOK; r = 0.77) 8-item questionnaire and Mathematics Teachers Communication Skills (MATECOS; r = 0.76) 13-item questionnaire. Their reliability coefficients were calculated using Cronbach Alpha. The data collected were analyzed using the mean and standard deviation. The results revealed that integration of the levels of Mathematics Teachers' TPACKC promote effective Mathematical Communication between in-service teachers. It was recommended that in-service teachers should popularize the use of TPACKC in their teaching-learning scenarios.

Keywords: *In-Service Teachers, Mathematical Communication, TPACKC Model*

How to Cite: Samson Sunday AFOLABI; Debo Sulaimon ARIKEWUYO (2025). Examining TPACKC Levels for Effective Mathematical Communication among in-Service Teachers. *International Journal of Innovative Science and Research Technology*, 10 (1), 2130-2136. https://doi.org/10.5281/zenodo.14848317

I. INTRODUCTION

We are in a dynamic environment that demands new innovative ways of teaching and learning despite the vast literatures on the use of Technological Pedagogical Content Knowledge (TPACK). This necessitate the need to move forward in adapting TPACK to meet the current and future realities we may envisage. This study serves as a building block for the emergence and crisscrossing of Mathematical Communication through the integration of a new model designed by the researcher known as TPACKC model. According to [5], Communication in Mathematics has been given a great deal of attention over the past 20years. Teaching is an activity that presumes some form of communication. With this in mind, these researchers went on to state that students will only retain 20% of what they hear; 30% of what they see and 50% of what they see and hear [5]. However, when teachers focus on interaction and communication in the classroom, students will retain 90% of what they say and do as they engage in discussions [5]. It is clear in this research that communications is an important factor in enhancing the quality of students learning and understanding in the Mathematics subject area. To further demonstrate the significance of communication in Mathematics, the National Council of Teachers of Mathematics [9] had included a communication standard as part of the Principles and Standards for School Mathematics.

According to [12], there is a great understanding for teachers that adopts discussions in and about Mathematics which are essential for the success of students and to their consolidated understandings of Mathematics concepts. It is clear that efforts must be taken to reduce the effects of the challenges - those over which teachers have the least influence which can inhibit the infusion of students discourse. In this sense, it is evident that greater support for verbal communication in Mathematics must be provided not only by teachers themselves but also administrators, curriculum developers and assessment developers in order for students to receive greater opportunities to succeed in Mathematics and gain greater confidence in themselves as Mathematicians. [10] in their study on communication in teaching and learning Mathematics observed that 86% of the teachers involved agreed that the process of communication in teaching and

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14848317

learning Mathematics occurs when both teachers and pupils are communicating and listening to each other. This type of communication whereby in teaching, the teacher explained mathematically, where else from the learning aspect, pupils communicated effectively through questioning and making arguments. Findings on the process of communication in teaching and learning, 8% of the teachers agreed communication starts first from the teacher with the pupils listen closely, then it follows by the pupils while the teacher will listen; and both the teacher and pupils communicate and listen to each other. Next, 3% of the teachers agreed that the process of communication in teaching and learning happens when pupils communicate and teacher only listen. On the other hand, 3% of the teachers agreed that communication in teaching and learning process occurs when teacher communicate; pupils listen and pupils communicate; teacher listen.

Ref [10] explained that on the use of communication in understanding Mathematical topic for teaching and learning process that does not directly involved the teacher as a facilitator; students were observed to have difficulty to understand the subject matter; for example, there are students who need to be guided first in introducing the concept or in problem-solving, students need guidance in writing the steps and techniques to solve the problem. Only then can students construct their own knowledge based on concepts and measures that have been taught and demonstrated by the teacher. [11] identified that Students' verbal and written communication; and discourse should not be underestimated. Communication and classroom discourse fulfill three broad and interlocking goals for learning, teaching and assessment. First, as students communicate their Mathematical thinking and reasoning, they become observers of themselves. They make invisible Mathematical solutions more clear and visible to themselves and to their peers; that is called metacognition (i.e. thinking about thinking). In addition as they explain their thinking and problem solving to their peers, they become teachers in the classroom. They become more confident in their abilities to do significant Mathematics. In this sense, they become more empowered mathematically [9]. Also, students' verbal and written communication helps their classroom teachers to understand students understanding. Therefore, Students' communication and classroom discourse not only enhances students learning but also, it inform teachers' instructional decision making. In this regard, classroom communication and discourse are powerful tools for teachers to assess students learning; and can create a safe environment for risk taking, exploring ideas and genuine dialogue. Furthermore, it may involve parents regarding their children education build a stronger communication between the classroom teacher and parents [16].

II. CONCEPTUAL FRAMEWORK

- *TPACK to TPACKC*

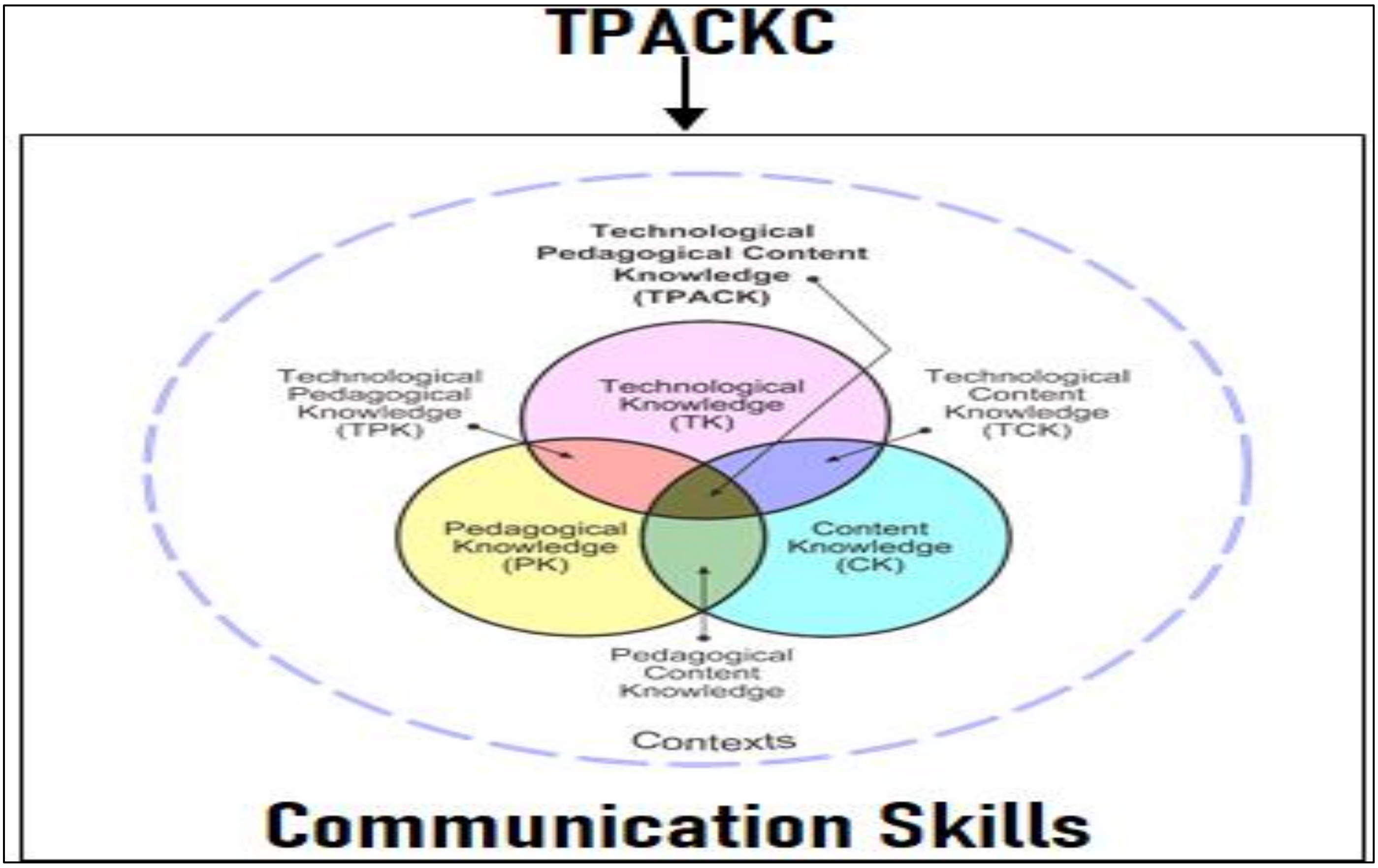

Fig 1 Researcher Designed TPACKC model, 2022
Source: TPACKC Model Adapted from TPACK [2]

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14848317

The **conceptual framework for this study** is the **Technological Pedagogical, Content Knowledge and Communication Skills (TPACKC) framework** which is an adaptation from the TPACK model [2], built on Shulman's pedagogical content knowledge (PCK) [13-14] as cited by [8]. TPACK framework stresses the importance of being aware of the appropriate technology used for teaching specific subjects [7]. In TPACKC, the communication skill creates the communication flow which explains the interaction process involved in linking technology, pedagogy and content knowledge using verbal and non-verbal ways. Mathematical Communication Skills (MCS) refer to the student's ability to:

- Arrange and link their Mathematical thinking through communications.
- Communicate their logical and clear Mathematical thinking to their friends, teachers and others.
- Analyze and assess Mathematical thinking and strategies used by others; and
- Use Mathematical language to express Mathematical ideas correctly [9].

➢ *Statement of the Problem*

Communication skills for Mathematics teachers is one of the core skills in the 21st century that must be embraced for effective content delivery and retention of Mathematical concepts. It is worrisome that some of the Mathematics teachers are not properly grounded in the use of technology, pedagogical skills; poor understanding of Mathematical concepts and have poor communication skills. These challenges needs to be addressed urgently if we must sustain learners' interest in Mathematics.

➢ *Purpose of the Study*

Specifically, the purpose of this study are:

- To determine the mean rating of the level of Mathematics Teachers' Technological knowledge.
- To determine the mean rating of the level of Mathematics Teachers' Pedagogical knowledge.
- To determine the mean rating of the level of Mathematics Teachers' Content knowledge.
- To determine the mean rating of the level of Mathematics Teachers' Communication skills.

➢ *Research Questions*

The following research questions guided this study:

- What is the mean rating of the levels of Mathematics Teachers' Technological knowledge?
- What is the mean rating of the levels of Mathematics Teachers' Pedagogical knowledge?
- What is the mean rating of the levels of Mathematics Teachers' Content knowledge?
- What is the mean rating of the levels of Mathematics Teachers' Communication skills?

III. METHODOLOGY

The study is a descriptive study that was carried out in Lagos State, Nigeria. A sample size of 95 in-service teachers were selected from 64 public junior secondary school in two educational districts. The selected districts were chosen because they had four zones each. The data were collected by the researcher. The collected data were properly sorted and analyzed; using mean and standard deviation to answer the research questions. A criterion mark of 2.5 was adopted for decision making, hence, a calculated mean greater than or equal to 2.5 is assumes to be high while a calculated mean value less than 2.5 is assumed to be low.

➢ *Instrumentation*

Four instruments were used for data collection after validation. These were trial-tested to ascertain their level of reliability.

- Mathematics Teachers Technological Knowledge (MATETEK)
- Mathematics Teachers Pedagogical Knowledge (MATEPEK)
- Mathematics Teachers Content Knowledge (MATECOK)
- Mathematics Teachers Communication Skills (MATECOS)

➢ *MATETEK –*

This questionnaire was rated on a four point scale; 1 for very low (VL); 2 for low (L); 3 for High (H); and 4 for Very High (VH). MATETEK consist of 7-item questionnaire to gather data from the respondents with regards to technological knowledge. The reliability coefficient for MATETEK gave 0.75 which was calculated using Cronbach Alpha.

➢ *MATEPEK –*

This questionnaire was rated on a four point scale; 1 for very low (VL); 2 for low (L); 3 for High (H); and 4 for Very High (VH). MATEPEK consist of 11-item questionnaire to gather data from the respondents with regards to technological knowledge. The reliability coefficient for MATEPEK gave 0.80 which was calculated using Cronbach Alpha.

➢ *MATECOK –*

This questionnaire was rated on a four point scale; 1 for very low (VL); 2 for low (L); 3 for High (H); and 4 for Very High (VH). MATECOK consist of 8-item questionnaire to gather data from the respondents with regards to technological knowledge. The reliability coefficient for MATECOK gave 0.77 which was calculated using Cronbach Alpha.

➢ *MATECOS –*

This questionnaire was rated on a four point scale; 1 for very low (VL); 2 for low (L); 3 for High (H); and 4 for Very High (VH). MATECOS consist of 13-item questionnaire to

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14848317

gather data from the respondents with regards to technological knowledge. The reliability coefficient for MATECOS gave 0.76 which was calculated using Cronbach Alpha.

IV. RESULTS

➢ *Research Question One*

What is the mean rating of the levels of Mathematics Teachers' Technological knowledge?

Results from Table 1 below showed that all the 7-item questionnaire had mean values above the criterion mark of mean value slated as 2.50. The grand mean of 2.95 indicated a high level of Mathematics Teachers' Technological knowledge (MATETEK).

Table 1 Levels of MATETEK

S/N	Items	Very Low (1)	Low (2)	High (3)	Very High (4)	Mean	Standard Deviation
1	I used different technology in my Mathematics classroom	5 (5.3)	16 (16.8)	52 (54.7)	22 (23.2)	2.96	0.784
2	I solve my own technical problems with digital technologies	4 (4.2)	23 (24.2)	48 (50.5)	20 (21.1)	2.88	0.784
3	I frequently play around with digital technologies	6 (6.3)	17 (17.9)	52 (54.7)	20 (21.1)	2.91	0.800
4	I keep up with important new digital technologies	9 (9.5)	11 (11.6)	46 (48.4)	29 (30.5)	3.00	0.899
5	I use digital technologies to represent Mathematical ideas	3 (3.2)	17 (17.9)	52 (54.7)	23 (24.2)	3.00	0.744
6	I adapt digital technologies to support learning in my classroom	6 (6.3)	15 (15.8)	43 (45.3)	31 (32.6)	3.04	0.862
7	I identify specific topics in the Mathematics curriculum where specific digital technologies are helpful in guiding student learning in the classroom	7 (7.4)	13 (13.7)	58 (61.1)	17 (17.9)	2.89	0.778
	Grand Mean and Standard Deviation					**2.95**	**0.807**

➢ *Research Question Two*

What is the mean rating of the levels of Mathematics Teachers' Pedagogical knowledge?

Results from Table 2 below showed that all the 11-item questionnaire had mean values above the criterion mark of mean value slated as 2.50. The grand mean of 3.23 indicated a high level of Mathematics Teachers' Pedagogical knowledge (MATEPEK).

Table 2 Levels of MATEPEK

S/N	Items	Very Low (1)	Low (2)	High (3)	Very High (4)	Mean	Standard Deviation
1	I use multiple teaching strategies when I solve Mathematical problems	4 (4.2)	6 (6.3)	51 (53.7)	34 (35.8)	3.21	0.742
2	I adapt lessons to improve student learning	2 (2.1)	9 (9.5)	46 (48.4)	38 (40.0)	3.26	0.718
3	I implement a wide range of instructional approaches	0 (0.0)	5 (5.3)	57 (60.0)	33 (34.7)	3.29	0.563
4	I organize my classroom environment for learning Mathematics.	2 (2.1)	11 (11.6)	46 (48.4)	36 (37.9)	3.22	0.732
5	I am able to assess student performance in a classroom	3 (3.2)	13 (13.7)	46 (48.4)	33 (34.7)	3.15	0.771
6	I make use of instructional materials that best represent Mathematics concepts	2 (2.1)	11 (11.6)	54 (56.8)	28 (29.5)	3.14	0.694
7	I have a good understanding of instructional materials that best represent Mathematical topics	2 (2.1)	5 (5.3)	53 (55.8)	35 (36.8)	3.27	0.659
8	I use instructional strategies that best represent Mathematical topics	3 (3.2)	7 (7.4)	49 (51.6)	36 (37.9)	3.24	0.725
9	I predict my learners' attitude when they enjoy the Mathematics lessons	4 (4.2)	8 (8.4)	49 (51.6)	34 (35.8)	3.19	0.762
10	I use strategies on Mathematical content to support students when they are learning Mathematics	5 (5.3)	6 (6.3)	42 (44.2)	42 (44.2)	3.27	0.805

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14848317

11	I use strategies on teaching approach to support student thinking during Mathematics lesson	0 (0.0)	9 (9.5)	51 (53.7)	35 (36.8)	3.27	0.626
	Grand Mean and Standard Deviation					**3.23**	**0.710**

- *Research Question Three*

What is the mean rating of the levels of Mathematics Teachers' Content knowledge?

Results from Table 3 below showed that all the 8-item questionnaire had mean values above the criterion mark of mean value slated as 2.50. The grand mean of 3.31 indicated a high level of Mathematics Teachers' Content knowledge (MATECOK).

Table 3 Levels of MATECOK

S/N	Items	Very Low (1)	Low (2)	High (3)	Very High (4)	Mean	Standard Deviation
1	I have a good understanding of students' conceptual and practical understanding of Mathematical concepts	4 (4.2)	10 (10.5)	43 (45.3)	38 (40.0)	3.21	0.798
2	I have a good understanding of the Mathematics curriculum that meets students' needs for learning Mathematics	2 (2.1)	8 (8.4)	40 (42.1)	45 (47.4)	3.35	0.726
3	I reason mathematically when I solve problems in my daily life	2 (2.1)	8 (8.4)	37 (38.9)	48 (50.5)	3.38	0.732
4	I am able to teach very well because I know the subject	1 (1.1)	6 (6.3)	39 (41.1)	49 (51.6)	3.43	0.663
5	I am able to solve Mathematics problems easily with my learners after giving them practical examples	3 (3.2)	3 (3.2)	50 (52.6)	39 (41.1)	3.32	0.688
6	I have a good understanding of the Mathematics curriculum that meets students' needs for learning Mathematics	3 (3.2)	8 (8.4)	46 (48.4)	38 (40.0)	3.25	0.743
7	I am able to relate Mathematical topics and formula to everyday activity	1 (1.1)	6 (6.3)	52 (54.7)	36 (37.9)	3.29	0.634
8	I am able to teach my learners how to prove and relate Mathematical tasks based on their previous learning experiences	3 (3.2)	9 (9.5)	44 (46.3)	39 (41.1)	3.25	0.757
	Grand Mean and Standard Deviation					**3.31**	**0.719**

- *Research Question Four*

What is the mean rating of the levels of Mathematics Teachers' Communication Skills?

Results from Table 4 below showed that all the 13-item questionnaire had mean values above the criterion mark of mean value slated as 2.50. The grand mean of 3.11 indicated a high level of Mathematics Teachers' Communication Skills (MATECOS).

Table 4 Levels of MATECOS

S/N	Items	Very Low (1)	Low (2)	High (3)	Very High (4)	Mean	Standard Deviation
1	I am able to communicate with my learners effectively when I use any digital device	6 (6.3)	13 (13.7)	48 (50.5)	28 (29.5)	3.03	0.831
2	I think deeply about how my verbal and non-verbal communication influence the performance of my learners	0 (0.0)	8 (8.4)	53 (55.8)	34 (35.8)	3.27	0.609
3	I make mathematical connections with the problems outside of Mathematics	5 (5.3)	10 (10.5)	45 (47.4)	35 (36.8)	3.16	0.816
4	I am able to communicate mathematically	3 (3.2)	10 (10.5)	56 (58.9)	26 (27.4)	3.11	0.707
5	I use probing questions to sustain active communication in my Mathematics class	1 (1.1)	12 (12.6)	57 (60.0)	25 (26.3)	3.12	0.650
6	I am anxious when communicating Mathematics knowledge and ideas to my learners	13 (13.7)	14 (14.7)	47 (49.5)	21 (22.1)	2.80	0.941
7	I am anxious in using technology to communicate Mathematics knowledge and ideas to my learners	10 (10.5)	18 (18.9)	50 (52.6)	17 (17.9)	2.78	0.865
8	I make some gestures in expressing disapproval of wrong response from my students	4 (4.2)	18 (18.9)	51 (53.7)	22 (23.2)	2.96	0.771

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14848317

9	I make some gestures in expressing approval of correct response from my students	2 (2.1)	10 (10.5)	52 (54.7)	31 (32.6)	3.18	0.699
10	I command applaud for brilliant response from my students	3 (3.2)	7 (7.4)	46 (48.4)	39 (41.1)	3.27	0.736
11	My voice is loud enough for all students to hear from the back of the classroom without straining their ears	2 (2.1)	7 (7.4)	38 (40.0)	48 (50.5)	3.39	0.719
12	I use local language where necessary as an alternative to express myself whenever my students find it difficult to understand the Mathematics concept	3 (3.2)	8 (8.4)	51 (53.7)	33 (34.7)	3.20	0.723
13	I tell stories or jokes to communicate my Mathematics ideas	3 (3.2)	6 (6.3)	53 (55.8)	33 (34.7)	3.22	0.702
	Grand Mean and Standard Deviation					**3.11**	**0.773**

V. DISCUSSSION OF FINDINGS

The study examined the levels of Mathematics Teachers' TPACKC. The study was guided by four research questions. The study clearly indicated that the integration of TPACKC promotes Mathematical Communication. This view is supported by [1; 6; 12; 5]. It is important to note that researchers like [4] suggested the significance of training teachers who can integrate technology into their fields in teacher training programs. Therefore, it is critical to carry out practices on teacher training programs that would enable pre-service (and in-service) teachers to enhance their TPACKC levels.

VI. CONCLUSION

This study concluded by examining relevant literature of authors that have worked in the area of TPACK [15] and delved further to propose a new version known as Technology, Pedagogy, Content Knowledge and Communication skills (TPACKC). It is the belief of the researcher to disseminate this new initiative to everyone concerned with qualitative education delivery. The use of excellent communication skills cannot be over-emphasized in the process of achieving the previously stated learning objectives [3]. Educational goals at the local, state, national and international level can only be realistic and fulfilling if there is proper communication among all stakeholders and participants.

RECOMMENDATIONS

➢ *These Recommendations are Based on the Findings of this Study:*

- Regular pre-service and in-service teachers training and workshop session on how to incorporate the use of TPACKC model.
- Periodic review of the curriculum-in-use.
- Regular feedback should be provided at every point in time before, during and after class assessment and evaluation process.

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