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Introducing IWB to preservice mathematics teachers: An evaluation using the TPACK framework

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Abstract

The study used the intervention mixed methods design to evaluate the technological, pedagogical and content knowledge (TPACK) of mathematics preservice teachers while doing their lesson planning and teaching with interactive whiteboards (IWBs). The method has the following parts: (1) qualitative data collection to establish the priority competencies for the intervention, (2) conducting a single-subject experimental design to equip the preservice teachers with technology-enhanced lessons and (3) final qualitative data collection on experiences in planning and teaching with IWBs. The results revealed that the TPACK framework reflects improvements in lesson planning and teaching demonstration skills of the preservice teachers. While the preservice teachers quickly responded to digitise their lesson activities, the formulation of lesson objectives is left behind. Thus, in lesson planning and teaching with IWBs, the pedagogical skills must align with the technological skills they expect to employ. Although the Philippine basic education is not fully implementing IWB technologies in the classroom, policymakers may want this technology to become part of the system.

Keywords: Interactive whiteboard, mathematics teaching, TPACK, preservice teachers, educational technology.

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1. Introduction

Interactive whiteboard (IWB) paired with the graphing utility software has changed the landscape of teaching and learning mathematics subjects for 21st-century learners. The IWB allows a complex environment in which presentation, texts and images, merging with software programmes (e.g., GeoGebra), can be controlled directly on a multi-touch screen by teachers and students. The literature regarding IWBs in mathematics education, on the other hand, revealed multifaceted dimensions. The utilisation of IWB technology in mathematics teaching has been well-explored, especially in advanced countries (Balta & Duran, 2015; Chen, Gamble, Lee & Fu, 2020; De Vita, Verschaffel & Elen, 2018; Hwang, Jia-Han, Yueh-Min & Jian-Jie, 2007) and with embedded dynamic mathematics software to maximise the features of IWB (Erbas, Ince & Kaya, 2015; Hwang et al., 2009). Learning mathematics with an IWB has been highly rated by teachers and students, which positively changes the students' attitudes towards learning (Balta & Duran, 2015) and improves strategic ways to utilise IWB on the part of the teachers (Redman & Vincent, 2015).

With the development of the graphing utility software, specifically in mathematics teaching, educators need to construct digitalised lesson planning to make a zippy explanation of the abstract concepts in mathematics in the real-world context (Walters, Green, Goldsby, Walters & Wang, 2016). Exposure of the preservice teachers to digitalise their materials would enable them to add support for students to enhance their learning. For example, scaffolding through digital gameplay is enabled in accordance with students' comprehension (Sun, Ruokamao, Siklander, Li & Devlin, 2021). These activities are best illustrated with an IWB and can even promote a collective learning experience in the form of a shared dynamic dialogic space (Kershner, Mercer, Warwick & Kleine Staarman, 2010).

Teaching with an IWB must be conveyed through relevant pedagogical content knowledge (PCK) (Holmes, 2009), such as small group dynamics with shared cognition facilitated by the teacher as an offshoot (Redman & Vincent, 2015) and problem-solving projects to integrate technology in mathematics education (Walters et al., 2016). The pieces of literature, as mentioned earlier, used the framework of Koehler and Mishra (2009) on technological, pedagogical and content knowledge (TPACK) to uncover the teaching–learning process, while the teachers digitalised their teaching material (Figure 1). They describe TPACK as the foundation of technology integration in teaching, which requires an in-depth understanding of the presentation of concepts combining technological and pedagogical techniques to support a constructive system to teach the content (Mishra & Koehler, 2006). The notion of TPACK is on a 'transformative' learning experience with the affordances of technological tools and how it could be utilised to develop or strengthen the old knowledge. Thus, teachers must fit in the technology with actual content in meaningful ways to enhance student learning (Holmes, 2009). The main idea is how the technology (such as IWB) is best used following the content, giving concrete learning pathways.

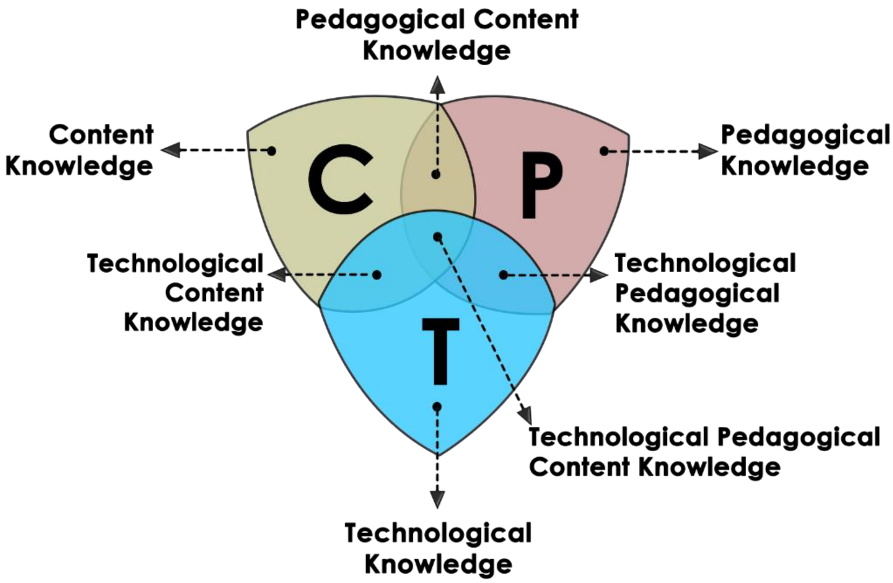

Figure 1. TPACK Schema (Mishra & Koehler, 2006)

Mishra and Koehler (2006) figuratively refined Shulman's framework making technology a significant factor aside from pedagogical and content aspects in teaching. The background of the TPACK framework is based on the earlier work of Shulman (1986). Shulman figuratively illustrates the distinction between content knowledge (CK) and pedagogical knowledge (PK) with a specific categorisation of PCK. Koehler and Mishra (2009) have extended the PCK framework of Shulman and inserted technological knowledge (TK) as a significant variable encompassing the present teaching context. The current theory serves as the foundation of effective teaching with technology. This requires understanding the triple representation of concepts on the technological application in education, pedagogical techniques and active ways to teach the content.

A general concept emerging from related studies is how good teachers are in employing pedagogical approaches to shelter IWB in the classroom effectively. There are shared concerns among IWB users, specifically on pedagogical and technological aspects. For example, a teacher's proficiency in using technology leads to failure on the part of the teachers to take advantage of the interactive and innovative features of IWBs (Chen et al., 2020; De Vita et al., 2018). Instead, IWBs were utilised only as ordinary whiteboards and as a presentation projector. Although several studies advocate that the usage of IWBs has constructive effects on teachers as they attract student's attention and sustain attentiveness (Bakadam & Asiri, 2012; Chen et al., 2020; Glover, Miller, Averis & Door, 2007), the question as to how the preservice teachers were trained to pin down the advantages to IWB tools is still wanted in developing countries like the Philippines. Currently, the government policy initiative for IWBs is not apparent in the Philippines, and no research has been conducted about uncovering qualitative and quantitative information about using the IWB among teachers.

This study's objective was to investigate what type of support IWB can be provided in developing technology-enhanced lessons (TELs) by applying the TPACK framework and to map the impact of these actions qualitatively. TELs refers to TK development using different technology tools (Chai, Koh & Tsai, 2010) suited for IWB usage during teaching demonstration. The idea is to introduce the IWB to preservice mathematics teachers and measure its impact on their TPACK in mathematics teaching from lesson planning, developing their digital material for the topic, proper selection of examples and problem sets, content delivery and evaluation of student's performance.

2. Materials and methods

2.1. Research design

The study employed the intervention mixed methods design (IMMD) (Creswell, 2013) to evaluate the TPACK of secondary preservice mathematics teachers. Mixing is the term used to describe either of the three possible ways of presentation: (1) the qualitative data are merged with the quantitative data on one end of the sequence, (2) the data are kept separate on the other end of the arrangement or (3) analysis is combined in some way between the extremes of the continuum (Creswell, 2009). Figure 2 shows the schematic diagram of the IMMD.

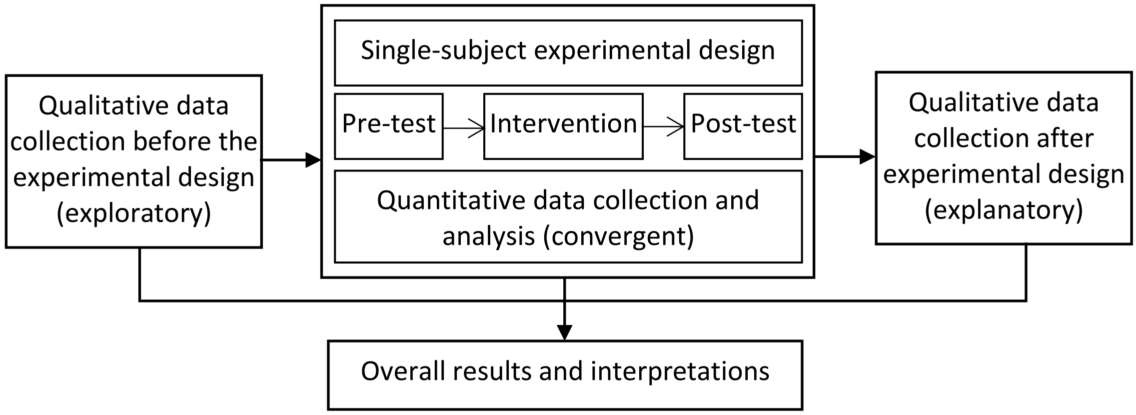

Figure 2. Intervention mixed methods design (Creswell, 2013)

The flow starts with qualitative data collection to frame the needed competencies for a single group pre-intervention and post-intervention quantitative analysis: the qualitative data collection uses focused group discussions (FGDs) and structured interviews with the participants. The intervention phase of the IMMD employed a single-subject experimental design. The design is best suited for a limited size or a small number of participants to establish the effects of an intervention on a single respondent group (Neuman & McCormick, 1995). The single group is both the treatment and control group. The study carried out the interventions in two phases: (1) a 32-hour duration in four sessions sets the PK development, while the preservice teachers were still waiting for their school assignments, and (2) another 32-hour seminar–workshops in four sessions were carried out on creating their own TELs.

The discussions of the intervention phase results were carried out together with the qualitative results to complete the IMMD cycle. The analyses after the experimental design are already connected. Connected to the IMMD means mixing quantitative and qualitative research is ‘connected between’ data analyses of the first phase and the experimental design's data collection (Creswell, 2009).

The study validated the quantitative analysis's overall results with the qualitative data by using technology and developing digital teaching material. The main objective of the study is to determine the impact of using the IWB on the TK, PK and CK of preservice mathematics teachers. Specifically, it seeks to delineate a pre-post evaluation improvement of the preservice teachers' PK and TK using a t-test of paired observation. TK will be evaluated in terms of technology learning and updates, solving technical problems and needing technical skills in teaching mathematics. The dean of the College of Education and the preservice teaching mentor did the PK evaluation to select a suitable teaching strategy for the topic and assess learning. The same is true with CK evaluation in determining examples and problem sets and integrating technology in various topics. These activities cover the preservice teachers' overall TPACK evaluation as they experience technology in the intervention phase.

2.2. Data collection

In total, 35 preservice mathematics teachers took part in the study. A preservice teacher (also known as a prospective teacher) is referred to as the teacher candidate in their final year of education and teacher training. The preservice teachers have acquired the skills and can transfer the necessary knowledge to their students when employed in the teaching profession (Tezer, Yildiz, Bozkurt & Tangul, 2019). The inclusion criteria of the participants were through a course seminar on technology in mathematics. The first qualitative data collection was the semi-structured interviews that were used to establish the digital competencies of the respondents. The identified digital competencies will serve as the basis for developing TELs. The teachers developed learning material with all of the affordances and limitations of software, such as graphing utility software, computer algebra systems, geometry expressions and many others (Chai et al., 2010). The intervention part was the seminar on technology in mathematics with workshops in teaching demonstrations by preservice teachers using their developed learning activities. The intervention phase establishes before and after TPACK competencies. It was in the form of an 80-hour course on the utilisation of the IWB in a classroom. FGDs were carried out after the intervention phase to capture the qualitative data on experiences. The interview guide of the semi-structured interviews and FGDs passed the expert panellists' evaluation of the general appropriations act (GAA) funding of Cebu Technological University, Cebu, Philippines. To get a good grasp of preservice teachers' experience, we did 10 FGDs, 5 groups with 3 informants and another 5 groups with 4 informants. The grouping was done based on the homogeneity of the TELs.

2.3. PK development

A 32-hour duration in four sessions sets the PK development, while the preservice teachers were still waiting for their school assignments. The theoretical understanding of 'using model strategies for integrating technology into teaching' (see Education, 2002) is the training's focus. The activities will provide learning and unlearning of proven ICT models and strategies, such as multimedia presentation, web-based lessons, online discussions and telecomputing projects. For example, the mathematics curriculum of grade 8 in K–12 contains the axiomatic structure of geometry. They may present the ideas using the identified graphing utility software and conduct collaborative research by the group in a flipped classroom. The understanding of different pedagogical approaches suitable for the topic is the primary purpose of flipping. They also learn classroom management, especially that most of the topics are web-based.

2.4. TK development

Another 32-hour seminar–workshops in four sessions were carried out on creating their own TELs. Group dynamics will be conducted to organise tutorial groups. Each tutorial group will choose two to three TELs most relevant to their teaching subject through joint negotiation with their student teaching adviser. Each TEL will provide the preservice teachers with resources for skill-based practice and scaffold them with design activities to generate lesson ideas applicable to the students they expect to teach.

2.5. CK enhancement

By default, content knowledge is part of preservice teachers' expertise since they have been studying the Bachelor of Science in Secondary Education and majoring in mathematics in 3 years. They are considered subject matter experts. However, as they develop their PK and TK, preservice teachers will hone the CK skills by providing the best problem sets in the technology integration to their daily lessons.

For example, GeoGebra's affordances explain hyperbolic functions' dynamics (Ljajko, Mihajlovic & Pavlicic, 2010; Wassie & Zergaw, 2019) as the distance of the vertices and foci changes and are more visible with an applet of equations in it. GeoGebra is an open-source dynamic geometry software (DGS) that supports the construction of plane and solid figures (Birgin & Acar, 2020) and promotes discovery learning through guided instructions (Dikovic, 2009). Experiences on DGS will enhance CK as they create their TEL. Quantitative evaluation of PK, TK and CK followed a standard rubric of the university. The evaluation was carried out by the dean of the College of Education and preservice teaching mentors.

3. Results and discussions

3.1. Pre-intervention qualitative data analysis

The semi-structured interview was designed to evaluate preservice teachers' prior knowledge on the following parts of lesson planning: (1) technology used in the instructional activities, (2) digital materials in teaching and (3) digital materials in evaluation. The transcripts of semi-structured interviews were organised by the NVivo software. Finding the nodes on the text query based on the responses was carried out using the dynamic text query tools, while evaluating nodes using a comparison diagram.

An NVivo-generated comparison diagram based on the most preferred nodes revealed that 15 nodes were associated with the use of GeoGebra, while 7 were in Desmos. GeoGebra and Desmos are the two graphing utility software that the preservice teachers are using. Response clusters revealed that there are more experiences in using GeoGebra than in Desmos.

> I already knew about the graphing software, which is the GeoGebra. It was introduced to us by our Instructor, and I found it very interesting. I was able to make a project in graphical proof of the Pythagorean Theorem. It helps the students grasp the concept more (Informant 1 of Group 2).

Therefore, it is more convenient to focus on the intervention part with GeoGebra. The development of instructional activity in the intervention part of this research was focused on using GeoGebra. The results lead the author to design a 24-hour seminar in three sessions in preparing instructional activity with an emphasis on the usage of GeoGebra.

On the evaluation part of the lesson planning, interview transcripts showed that all were able to experience Kahoot software, but with some setbacks. Kahoot is a game-based online software that is generally used to evaluate students learning. One of the setbacks is creating more complex applied mathematics problems, especially when the item involves graphs. A more favoured usability is the Schoology, a learning management system that enables teachers to create test items even with other graphing utility in an applet. With these results, the intervention plan was devised to cover preservice teachers' training to improve their skills specific to IWBs in the classroom.

3.2. Quantitative and qualitative results after the intervention

TK and PK pre-assessments were established using the lesson plan's evaluation and a 15-minute topic presentation with the instructor. The lesson plans based on a TEL rubric were rated by the dean of the College of Education. There was no initial evaluation for CK since the incoming preservice teachers are considered subject matter experts (Holmes, 2009). The final teaching demonstration lesson was graded with TPACK using a demonstration lesson assessment rubric. The use of IWBs in the classroom is the first guide of the assessment. Table 1 presents the pre-TK and pre-PK of preservice teacher respondents.

Table 1. Pre- and post-evaluation of pedagogical knowledge – TEL lesson planning component

Lesson plan components	Before intervention	Verbal description	After intervention	Verbal description
Objectives	3.71	Meets expectations	3.51	Meets expectations
Activities	3.46	Meets expectations	3.83	Meets expectations
Introduction	3.60	Meets expectations	3.66	Meets expectations
Closure	3.03	Needs improvement	3.77	Meets expectations
Meeting Individual Needs	3.43	Meets expectations	3.69	Meets expectations
Evaluation	3.37	Needs improvement	3.77	Meets expectations
Organization and Quality	3.69	Meets expectations	3.69	Meets expectations

Table 1 shows that four of the technology-enhanced lesson plan components have a higher average after the intervention of seminar-type classes in technology use in the classroom. At the same time, the organisation and quality remained the same. The objectives of the lesson plans are included to a satisfactory level. The activities are objective-based, and the introductory part is attention-getting, which taps prior knowledge. None of the lesson plan components obtained the highest qualitative description, which is 'exceeds expectations'. The focused group discussion (FGD) revealed several themes that support quantitative results. For example, there is recognition that technology inside the classroom meets the future's needs ($n = 6$).

> Technology use gets the student's attention. Technology makes the broadening of the topics easier. The examples can be more realistic and are related to the current society (Group 4 Informant 1).

> The use of technology is essential to modern-day students. The students' learning will be at stake if there is no technology in the teaching-learning process (Group 6 Informant 2).

It is noteworthy that the lesson plan's objective component decreases from before intervention to after intervention. The lesson's competencies proper with the technological application are more diverse than that of the traditional method. Therefore, additional training for preservice teachers' skills in formulating lesson plan objectives for 21st-century learners and the use of IWB is required. The overall verbal description could deduce that the PK of preservice teachers' lesson planning component 'meets expectations'. The only two results with a verbal description of 'needs improvement' are the before intervention lesson planning parts on 'evaluation' and 'closure'. The reason is that none of them created digital evaluation tools in the initial lesson planning and the lack of online reading resources. The digital evaluation tool is vital in teaching with an IWB, especially for abstract concepts that can be made visible using programmed applets performing specific mathematical modelling tasks.

> Before: I have not encountered or tried any digital application for evaluation. All of my evaluation parts are usually in paper and pencil test or the form of activity.

> After: Schoology with GeoGebra applet makes assessment interactive and measures the students' competency more efficiently (Group 3 Informant 1).

Technological inclusion in lesson planning is not yet a necessity among preservice teachers. The student teaching mentors need to tell them or perhaps they lack training. There is a need to develop their TELs. One of the emerging themes is the need for more practice with technological applications, especially in making applets to illustrate abstract ideas in mathematics visible (n = 4).

> Although many technology-based teaching methods are available for the teachers, many educators still encounter difficulties using technology. In promoting digital literacy in the teaching-learning process, educators must be trained well to support the system. The key objective of teaching with technology is to improve technology to achieve academic achievement (Group 5 Informant 3).

Table 2. Pre- and post-evaluation of pedagogical knowledge – teaching demonstration component

Teaching demonstration components	Before intervention	Verbal description	After intervention	Verbal description
Objectives	3.34	Exemplary	3.49	Exemplary
Focus/Entry activities	3.20	Proficient	3.46	Exemplary
Instructional activities	3.34	Exemplary	3.43	Exemplary
Presentational style	3.34	Exemplary	3.43	Exemplary

Table 2 shows that, on average, preservice teachers are exemplary in terms of teaching demonstration. Notably, these preservice teachers are homogeneous due to entry requirements and retention policy imposed in the College of Education. It is empirical that the teaching–learning process has become more involved with net-savvy students in the 21st-century classroom. Pedagogy is focused more on instructional activities needed to succeed in life in the modern day. The focus/entry activities and objectives components improved from proficient to exemplary. One of the themes emerging from experiencing teaching with an IWB is the advantages of using GeoGebra in teaching mathematics (n = 12). GeoGebra is one of the topics included in the seminar-type TELs in the study's intervention process.

> So far, the only thing that I have been commented on or complemented to is the use of GeoGebra. They are very eager to know more about it and explore what GeoGebra can do. The discussion always gets the attention of the students. They are very keen to know GeoGebra since it is new to them. The students are also very participative in manipulating GeoGebra as they do the activity (Group 8 Informant 3).

All others are still exemplary with the instructional activities decreasing. The lack of experience in using the IWB is the very reason for disruptions in the teaching activities. Failure on the part of preservice teachers to explore the manipulation of the graphing utility application will result in some technical problems along the way. For example, during the final demonstration, one is told that he/she must check his/her command beforehand to avoid errors in graphing. There were comments (n = 4) that the teacher needs to learn more in using the IWB, especially when it involves students in the activity part.

Table 3. Pre- and post-evaluation of technological knowledge

Component/ competencies	Before intervention	Verbal description	After intervention	Verbal description
Use of technology in teaching	3.20	Proficient	3.54	Exemplary
Developing their own digital material for teaching	3.40	Exemplary	3.74	Exemplary
Developing their own digital material for evaluation	2.57	Proficient	3.66	Exemplary

Table 3 reveals that technology in teaching, developing digital material for teaching demonstration and developing digital content for evaluation increases before the intervention. These three competencies were the prevailing themes in the FGD interviews in the first part of the IMMD. These observations also point to considering the effective incorporation of technology into the classroom, a key component of emergent TPACK. In general, the students' explanations support the conjecture that they know the complexity involved when planning potentially useful IWB learning activities.

Table 4. Paired samples t-test of the scores on the PK teaching demonstration

Technological knowledge	Pre-mean	Post-mean	t-value	p-value	Findings
Objectives	3.34	3.49	1.56	0.06	Not significant
Focus/Entry activities	3.20	3.46	2.60	0.01	Significant
Instructional activities	3.34	3.43	0.69	0.25	Not significant
Presentational style	3.31	3.49	1.89	0.03	Significant

Level of significance: $\alpha = 0.05$

Table 4 reveals that the focus or entry activities to introduce the lesson proper improved significantly ($p = 0.06$) from pre-intervention to post-intervention. This component is one of the most challenging tasks since it involves making digital materials to connect the previous lesson to the new one. The significant increase ($p = 0.00$) in activities in the lesson plan component supports the results. The presentational element also has increased with a significant p-value at 0.03. Other TK components appeared to be higher in the post-intervention, but the differences are insufficient to yield significant results.

Table 5. Paired samples t-test of the scores on the TK teaching demonstration

Technological knowledge component	Pre-mean	Post-mean	t-stat	p-value	Findings
Use of Technology in Teaching	3.20	3.54	4.25	0.00	Significant
Developing their Own Digital Material in Teaching	3.40	3.74	3.78	0.00	Significant
Developing their Own Digital Material for Evaluation	2.57	3.66	10.90	0.00	Significant

Level of significance: $\alpha = 0.05$

As seen in Table 5, all TK components in the preservice teachers' teaching demonstration showed significant improvements from pre-intervention to post-intervention (all $p = 0.00$). The exposure of preservice teachers in planning to teach with an IWB resulted in an effective digitation of the activities.

After the single-subject experimental set-up, FGDs were facilitated to complete the IMMD. The guide questions include six open-ended questions on the inclusion of technology in the classroom, probing questions on the quantitative analysis results. The qualitative responses were analysed using NVivo Pro, and a Word Cloud was generated using the transcripts of the FGD, as shown in Figure 3.

Figure 3. After intervention FGD word cloud

In the parlance of qualitative analyses, Word Cloud is one of the most effective ways of looking for themes. Figure 3 shows that the most frequently mentioned words in the Word Cloud of FGD transcripts are ‘technology’ ($n = 350$), ‘students’ ($n = 350$) and ‘teaching’ ($n = 255$). Each of these words found in the transcripts depicts the different ideas.

Although there is a natural association of the term 'technology' to IWB integration, the fascinating part is how the ideas are mentioned differently with specific frequency comprising subthemes. For example, 12 of the informants claimed that IWB integration is essential in mathematics teaching. This finding supports De Vita et al.'s (2018) work stating that IWB promotes problem-solving activities in mathematics throng intensive use of dynamic geometry software.

The use of IWB has a significant impact on student's learning (Group 6 Informant 1). Tech made a high impact on my teaching. I feel like I am smarter while using technology. As I go beyond my lesson's content, students are amazed because they see how education works on IWB and graphing software (Group 1 Informant 1).

Another common subtheme on the word 'technology' was that technology makes the teaching–learning process more realistic, exciting and enjoyable ($n = 8$). These findings support the idea that technology in teaching offers unprecedented opportunities to influence learners' technologically mediated participation in classes (Kessler, 2018). Below are some of these claims.

Technology can augment relationships between teachers and students. It helps make teaching more meaningful and fun (Group 1 Informant 1). Learners will become aware of the technology's fast progress and that they are more interested in-class activities. They are learning, but they are enjoying it (Group 4 Informant 2).

Also, preservice teachers claimed that the use of 'technology' saves time preparing the lesson and more time developing CK ($n = 5$). Using an IWB is time-saving (Holmes, 2009). The students came to appreciate the software's organisational potential and the ease with which material can be reviewed and accessed from time to time.

Technology makes planning for the class very time-efficient (Group 2 Informant 1). Because of technology, I can spend less time on my instructional materials, more time understanding my topic, and extra time thinking for effective teaching strategies (Group 4 Informant 1).

Balta and Duran (2015) argued that students' positive feelings towards the IWB might encourage teachers to use this interactive tool in the classroom. Aside from the overlapping use of the term 'technology' and 'students' in a single statement of the informants, the reference of the word 'students' to classroom management ($n = 8$) is also notable.

I can interact with my students more because of the proximity control. I can communicate with them more through the higher-order thinking questions prepared in the presentation (Group 4 Informant 1). Using IWB significantly improved my assessment, smooths my teaching method, and most especially caught my students (Group 5 Informant 2). The teacher could see the students' attention because of the GeoGebra (Group 6 Informant 2).

GeoGebra is an open-source online tool for graphing. IWB paired with graphing utility software such as GeoGebra is one of the best practices that enhance mathematics learning (Erbas et al., 2015). Another emerging subtheme under the word 'student' is that IWB improved student participation ($n = 8$).

The students are eager to participate when they are going to use technologies. My class is more on student engagement with classmates' work (Group 3 Informant 2). In lesson planning, I can now introduce more interactive activities so that more students can participate. There is eagerness among the students to use the IWB (Group 7 Informant 1).

Apart from the subthemes formed previously, it is interesting to note that the word 'teaching' also denotes that their teaching skills have changed because of technology ($n = 7$). This finding is essential in developing teachers' critical technology use since they are more inclined to learner-centred teaching beliefs (Admiraal et al., 2017).

My teaching changed because of technology; I have enough time for planning and using other techniques. It is less hassle (Group 5 Informant 3). Technology changed me a lot when I started teaching, especially in lesson planning (Group 7 Informant 2).

4. Implications

With the significant improvement in hypothesis testing on the paired observations of technological knowledge, it can be generalised that the IWB improves the teaching–learning process. The typical responses to the question 'What has not worked?' are as follows: (1) the schools do not have enough facilities, (2) the lack of training in technological applications and (3) untoward technical problems. The sad reality is that the use of IWBs in the Philippines' secondary education system does not exist in the majority of mathematics classrooms. In the Philippine context, few research articles have explored new technology's role in facilitating the K–12 curriculum (Almerino et al., 2020). Backfisch, Lachner, Hische, Loose and Scheiter. (2020) suggest that teachers' motivation plays a vital role in technological integration in mathematics classrooms. Thus, there is a need to craft policy directions to enhance teaching technical aspects, especially that support climates are an essential dimension of motivation to teach among Filipino teachers (Gonzales, Gonzales, Costan & Himang, 2020). Another result supporting our findings is the work of Van Laer, Beauchamp and Colpaert (2012), which revealed that teachers' TK is a relevant predictor for IWBs in schools. The more exposed the teacher is to IWB, the more he/he pushes policy directions to provide IWBs in the classroom.

5. Conclusion and recommendations

The TPACK framework can truly reflect important information in lesson planning and teaching demonstration skills of preservice teachers as they plan to teach with the IWB. The effective use of TELs enhances the capabilities of preservice teachers' TK. However, the skills acquired in lesson planning are not well aligned with teaching with IWB. To conclude, it is empirical that while preservice teachers quickly responded to digitise their lesson activities, the other side of pedagogical skills, especially in the formulation of lesson objectives, is left behind. Therefore, any plan to prepare the quick starter preservice teachers to teach with IWB must be accompanied by pedagogical skills aligned with the TK it expects to employ.

Although there are setbacks on the reality that the Philippine basic education system is not yet at the stage of implementing IWB technology in the classroom, incoming teachers' technological skills would help policymakers want these interactive tools to become part of the system. After the full implementation of the K-12 curriculum, the country's basic education must promote skills development in the digitalisation of important concepts that cannot be viewed in the old chalk and board teaching. Thus, the result of this study is of great help.

Finally, further research is recommended to generalise TPACK, taking into account some latent variables to explain the TK, PK and CK of mathematics teachers. Another study may be carried out to uncover the culture of mathematics teaching in the Philippine context and its extent to the students' perceptions of the teacher's TPACK.

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