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Mobile Interactive System in Virtual Classroom based on TPACK: A Study from Students' Perspectives

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Abstract. Journal of System and Management Sciences (JSMS) is a multidisciplinary journal, mainly publishes original research and applied papers on system and management sciences, including the application of system science and system engineering, mathematics and statistics, computer and information, operation research and the transition of education has occurred amidst the pandemic with the adoption of online teaching and learning. Even though technologies have been supporting online teaching and learning for years, the teachers' proficiency in the virtual classroom is yet to be determined as it is still relatively new. Moreover, the teachers were incompetent to integrate technology into their pedagogy. Hence, a mobile interactive system (MIS) is designed with the adoption of technological pedagogical and content knowledge (TPACK) framework. It serves the purpose of enhancing the teachers' online teaching experiences and effectiveness. Additionally, the proposed TPACK-based MIS framework was constructed via SMARTPLS v3.3.2. A research design of one-group pretest-posttest quasi-experimental was implemented to collect experimental sample data. The data were analyzed through the proposed framework. A moderating effect, an interacting effect on the relationship between TPACK and technological pedagogical knowledge (TPK) was observed through the analyzed results. Furthermore, the MIS is an essential moderator variable to enhance the teachers' teaching effectiveness in the virtual classroom management, modeling and simulation.

Keywords: teaching effectiveness, virtual classroom, TPACK, mobile interactive system, online learning, COVID-19.

1. Introduction

Ever since the Covid-19 epidemic, the education sector has drastically changed. The conventional classroom is getting replaced by the virtual classroom in educational institutions. Hence, the relevancy of the traditional teaching approach in education nowadays is weeding out where the virtual classroom can be a game-changer (Dr Saminathan .R; Hemalatha .p, 2021). The usage of conventional teaching tools in the virtual classroom is hindering as these tools are not designed for the online classroom (Winarno et al., 2018). Therefore, the discovery of alternatives to conventional teaching tools is a necessity. Apparently, online real-time video conference platforms such as Zoom, Microsoft Teams, and Google Meet are preferred by most education institutions (Pratama et al., 2020). These platforms allow teachers to conduct online classes. For instance, Google Meet has JamBoard, which replaces the physical whiteboard (Gonsalves et al., 2021). It grants teachers an alternate way of presenting teaching materials. However, teachers might not be as familiar with mouse and keyboards in conceptualising the teaching materials.

In addition, the teacher-student interaction in online classes is affected negatively. Teachers find it difficult to engage students during online classes, whereas students find it difficult to catch up and understand the lessons taught (Deepika, 2020). Also, it is challenging to teach the subjects that involve mathematical problems in online classes (Islam et al., 2020). Hence, a complementary tool that helps teachers facilitate online classes is essential to address the challenges. The acquisition of new and expensive hardware for assisting the teachers in conducting online classes can be irrational as the effectiveness can be unknown. Alternatively, as smartphones are widely used, it is an ideal technology for assisting teachers in leveraging them in the virtual classroom. Most importantly, the ability to install a wide range of applications tailored for different purposes indicates its great versatility and capability. Hence. the technological pedagogical and content knowledge (TPACK) model is adopted to help to assess teachers' proficiency in their knowledge of pedagogical, content, and technological domains, as well as the, intersects of that three knowledge. It lets the teachers understand the 'know-how' in teaching and engaging their students effectively with lesson planning that involves technology (Hossain et al., 2020; Kapici & Akcay, 2020) Nonetheless, the insights of TPACK from the teacher's perspective may be biased and unconvincing as the assessment is done by the teacher him or herself (Fathi, 2019). Consequently, students' feedback on their teachers' TPACK efficacy gives more insights to teachers in constructing lessons according to the students' needs (Hossain et al., 2020).

Furthermore, concerns regarding the teaching environment were raised due to the pandemic resulting in transforming the classroom environment from conventional classrooms to online or virtual classrooms. Hence, the transformation led to the teachers' ineffectiveness in planning their teaching materials. In other words, teachers' readiness and understanding of the technology in terms of technology integration in

online classes was doubtful. Thence, it is essential to enhance the efficacy of the teachers' delivery methods when conducting online classes. Additionally, in conjunction with the technology involved in the new education norm, the teachers' proficiency in TPACK should be considered primarily from the students' perspectives.

Moreover, TPACK pre-post assessments were used to provide insights regarding the teachers' technological support (Graham et al., 2012). In addition, a mobile interactive system (MIS) with a lower learning curve was proposed and developed, offering freehand writing and synchronous display features. Besides, the TPACK framework is adopted in which the elements from the TPACK framework with higher loadings will be selected to construct a model.

2. Literature Review

2.1 Online learning

As digital learning is an umbrella term, online learning is a more specific term that best describes current education where most activities and coursework can be done via the Internet. According to Siti et al. (2020), digital learning integrates technology into educational activities to enhance students' learning experience(Abdul Bujang et al., 2020). In other words, teachers are starting to utilise and integrate technology to improve their teaching methods nowadays (Krishnasamy et al., 2020). Since the pandemic has significantly impacted the educational sector, most educational institutions were forcibly having classes shifted to online platforms. Back in the days before the pandemic, most educational institutions practised a conventional way of teaching where teachers were physically present in the classroom conducting face-to-face classes. In addition, over the past decades, no one envisioned the impacts and possibilities of technology integration in the educational sector (Leahy et al., 2019). Since social distancing is essential to crowd control to avoid unnecessary physical contact between each other, the implementation of the online class is a necessity, and it has slowly turned into a new norm (Xhaferi & Xhaferi, 2020). As far as what is being concerned lately, online learning has a great opportunity to unleash its potential amidst the pandemic. The online class is believed to improve the learning experience in terms of content understanding, especially the accessibility of recorded lectures (MANEA, 2021). However, it has been proved that theoretical subjects are best suited for the online learning approach, whereas more practical subjects are questionable (Khalil et al., 2020). The educational sector has entered a new era, and online learning is the most commonly practised during the pandemic. The integration and utilisation of technology play an essential part in online classes whereby teachers have to adapt themselves to this phenomenon and forgo the conventional way of teaching.

2.2 Virtual classroom

A virtual classroom is an online teaching and learning environment where the classes are conducted synchronously. The virtual classroom program was initially introduced by AT&T and launched in 1996. In the same year, the University of Illinois at Urbana-Champaign (UIUC) conducted an asynchronous virtual classroom to experimentally use computer and computer networks to enhance the learning process in higher education (Oakley, 1996). In the paper, the students have a positive attitude toward implementing a virtual classroom environment as it improves their learning exceptionally. Generally, the virtual classroom can be categorised as a synchronous or asynchronous virtual classroom (Maanvizhi et al., 2020). In the virtual classroom, students are leaning more toward the support and assistance from their educational institutions regarding guidance and resources (Murphy et al., 2020). In fact, the online classes conducted in virtual classrooms are usually in real-time, where the screen of the students and teachers are synchronous. Therefore, the virtual face-to-face session is possible, and engagement between teachers and students can be driven. In adapting to the virtual classroom, not only students but also teachers need to learn the technologies used for the virtual classroom which can be a challenge because not everyone is familiar with these technologies (Taylor S. Graalman & Dula, 2021). Video conferencing is one of the most common approaches being used in the educational sector for conducting classes, hosting online workshops (Lestiyanawati, 2020). In short, a virtual classroom is a replacement for the conventional classroom in which real-time classes are possible as the students are prohibited to join their classes physically at their campus.

3. Proposed Model: Mobile Interactive System

According to this paper, a MIS was proposed and developed. It is a mobile application for assisting teachers as a complementary tool for online classes. The features provided are the whiteboard-like freehand writing pad and synchronous display. These features were intended to replicate the physical classroom environment in the virtual classroom. As much as teachers rely on the whiteboard and marker pen in the conventional classroom, those figures and formulas can hardly be illustrated in the virtual classroom. Hence, the whiteboard-like freehand writing pad feature was tailored to address the known issues. It allows teachers to utilize it by installing the developed MIS into their smartphones and using it as a writing pad. The MIS is an alternative for use of the mouse and keyboard in the virtual classroom as it can be tricky when it comes to complex mathematical formulas in the online class. Furthermore, the synchronous display feature allows the teachers to share their writing pad screen with their students during the online class session. The overview of MIS is shown in Figure 1.

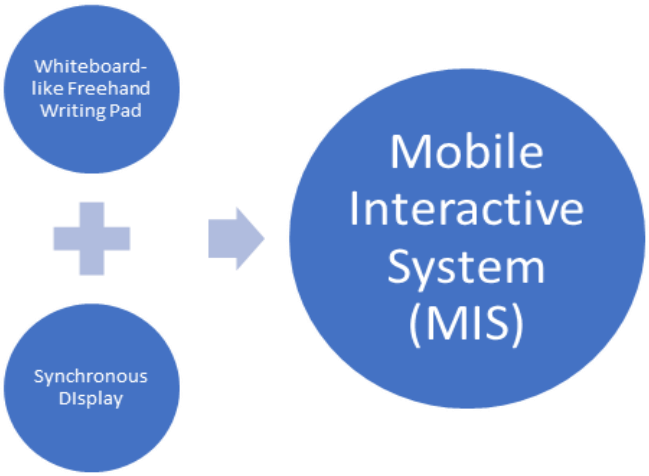

Fig. 1: Overview of MIS.

4. Experiment Design

A research design of quasi-experimental one-group pretest-posttest was implemented in this paper. A cluster sampling is applied. The cluster of this paper is the student who experienced online learning with the MIS features integrated. Cluster sampling is considered probability sampling, whereby this type of sampling method can reduce sample bias because the data collected through this sampling method represents the population better (Wu & Thompson, 2020). Moreover, the orthogonalisation approach was chosen as the calculating method for moderating effect because it aimed to maximise the endogenous construct's prediction where it provides high prediction accuracy (T. et al., 2018). Also, it is suitable for small sample sizes and fewer indicators per construct in which the sample size is smaller or equal to 200 and the indicators count is less than or equal to 4 for each construct. 38 students from a Malaysian private university taking the subject "Computer Organization and Architecture" were chosen. Throughout the trimester, this group of students was taught with the proposed MIS integrated into their online classes. It consists of two features mainly tailored for online classes: synchronous display and on-screen writing. The teacher uses the proposed MIS freehand writing pad feature to portray the subject's concept. In order to let students in viewing the teaching content illustrated on their teacher's mobile device, the synchronous display feature by the proposed MIS was utilised. The teacher's device screen is shared synchronously in the virtual classroom.

Other than that, two sets of questionnaires were prepared for the pre-test and post-test of the experiment. The questionnaire items adopted the TPACK framework (Elas et al., 2019). Originally, the TPACK framework was a self-assessment for teachers to measure their knowledge of the seven domains in the framework. However, according to Jalil and Saman (2019), teachers' self-assessment is questionable as it

may not be up to par with their thorough understanding of knowledge and practice solely depending on teachers' perspectives (Fathi, 2019). Hence, this paper focused on the students' perspective on teachers' TPACK instead. Additionally, TPACK from students' perspectives also helps in reducing the bias of self-assessment from teachers' perspectives (Chuang et al., 2018). Data is then collected and further analysed using SmartPLS v3.3.2.

5. Results

TPACK is known as an instrument that collects the self-assessment of teachers' knowledge about the TPACK framework domains (Niess, 2011). The TPACK framework consists of seven elements: TK, PK, CK, PCK, TPK, TCK, and TPACK. The TK, TPK, and TPACK are selected for further analysis in this paper as these elements are significant and with higher loadings than other elements based on the collected data from distributed questionnaires. Additionally, Figure 2 highlights the integration of MIS into the TPACK framework and how it fits the relative domains in the virtual classroom environment. As for the TK, MIS is used as an assisting tool in conducting online classes. As for the TPK, it defines teachers utilising MIS features in conducting online classes interactively. As for the TPACK, it indicates that teachers interactively teach with the MIS integrated into the online class for the subject matter. The virtual environment is the context of the mapped TPACK framework as the online classes are conducted.

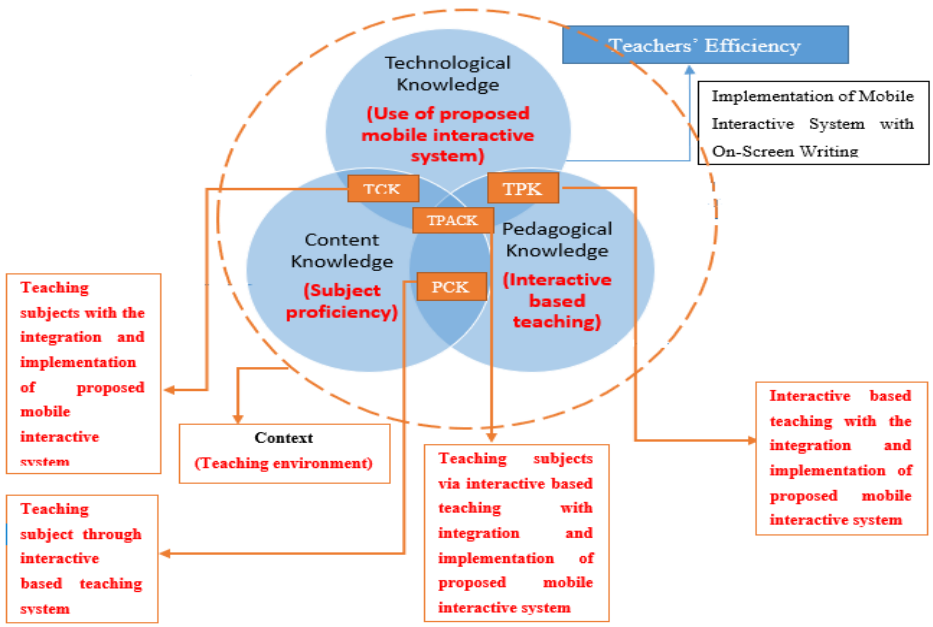

Fig. 2: TPACK Framework mapped with MIS and teacher's proficiency.

Hence, the proposed model was constructed with TK, TPK, and TPACK adopted from the known TPACK framework (Figure 2) and illustrated in Figure 3. The TK is adopted in this paper because it indicates whether the teacher understands the digital tool used, which is the proposed MIS in this context. Since the teaching materials and plan are prepared according to the syllabus given before the semester started, PK and CK have minimal impact on the paper. As this paper focused on how the teachers can utilise the proposed MIS in the virtual classroom conceptualising the subject matter, TPK is highly concerned as it indicates the teacher's understanding of the way of teaching using the proposed MIS. It changes the experience of teaching and learning. TCK is not considered in this paper because the proposed MIS does not transform or alter the teaching content where the teaching materials remained as to how it was planned. Unlike the other elements, TPACK served as the fundamental to the effectiveness of teaching with technology. Hence, it was taken into account in this paper. In addition, the indicators are selected based on the constructs' outer loadings. The outer loadings indicated the reflective measurement model estimated relationship. At least 49% of the variance of the indicator is explained by the latent variables when the outer loadings are > 0.7. The outer loadings were obtained through Partial Least Squared Algorithm

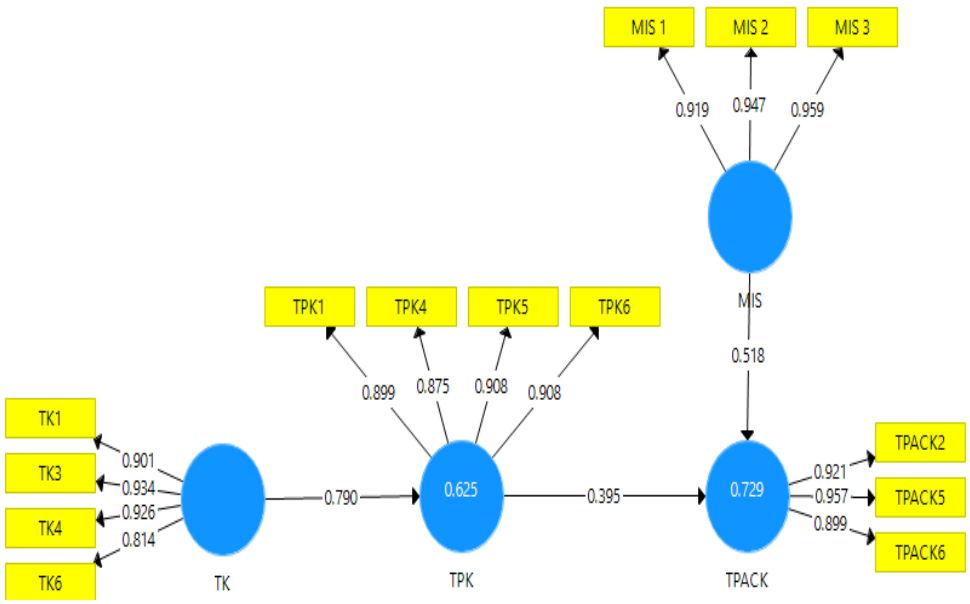

Fig. 3: Proposed model without moderating effect.

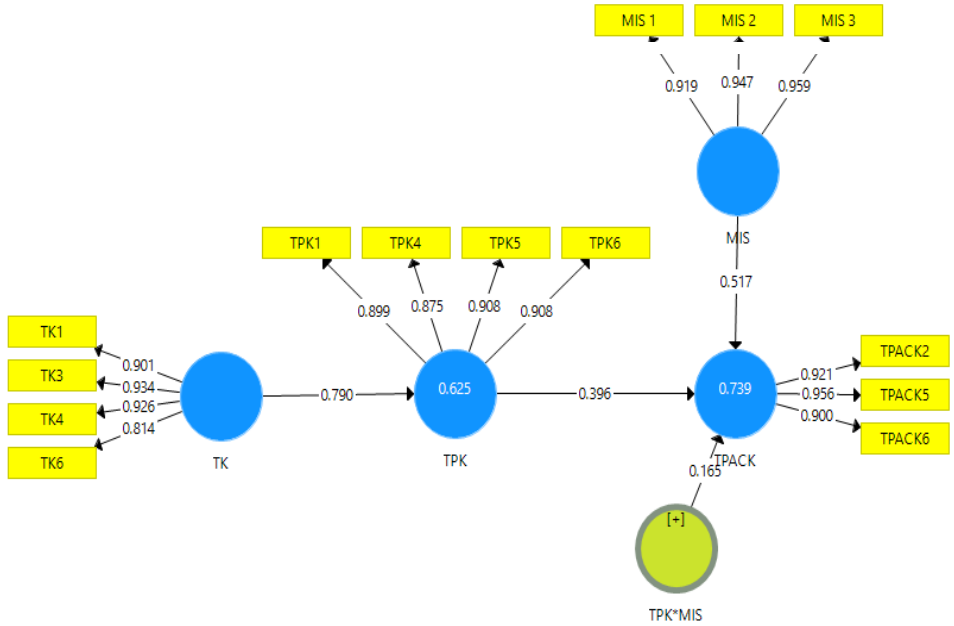

Fig. 4: Proposed model with moderating effect.

Firstly, the indicators of the constructs are trimmed through the Partial Least Square Algorithm (PLS) as shown in Table 1 and obtained in the model shown in Figure 3.

Table 1. Outer loadings of the constructs' indicators.

	MIS	TK	TPACK	TPK
MIS 1	0.959			
MIS 2	0.947			
MIS 3	0.919			
TK 1		0.901		
TK 3		0.934		
TK 4		0.926		
TK 6		0.814		
TPACK2			0.921	
TPACK5			0.957	
TPACK6			0.899	
TPK1				0.899
TPK4				0.875
TPK5				0.908
TPK6				0.908

Then, in Table 2, the reliability and validity of the constructs are examined. Hence, the average variance extracted (AVE) and composite reliability (CR) were inspected. The threshold value for AVE is > 0.50 whilst CR is > 0.70 (Lillian-Yee-Kiaw Wang, Sook-Ling Lew, 2020; Lin et al., 2020; T. et al., 2018). The CR and AVE in this paper met the threshold requirements. The CR values were above 0.90, and AVE values were above 0.80.

Table 2. Reliability and validity of the constructs.

	CR	AVE
MIS	0.959	0.887
TK	0.941	0.801
TPACK	0.947	0.857
TPK	0.943	0.805

In Table 3, the Heterotrait-Monotrait Ratio (HTMT) values were examined for the discriminant validity. The threshold value for HTMT is < 0.85 (Chuang et al., 2018; Taylor S. Graalman & Dula, 2021). The HTMT values in this paper are within or close to the threshold value. From Table 1, the R^2 of the main effect model, which was referred to as TPACK, is 0.729. From Figure 2, for the interaction effect model, the R^2 is 0.739.

Table 3. Heterotrait-monotrait ratio.

	MIS	TK	TPACK	TPK
MIS				
TK	0.846			
TPACK	0.870	0.845		
TPK	0.802	0.851	0.849	

In Table 4, the R^2 change of 0.010 indicates that with the addition of one interaction term, the R^2 has changed about 1%, which means MIS have a moderating effect between TPK and TPACK (Ahmed et al., 2013). Next, the effect size (f2) was calculated based on Equation 1 (1). The effect size is 0.039. Based on the f^2 of 0.039, it concluded that the effect size is large (Aguinis et al., 2005). The moderating effect has a significant effect, meaning it was a crucial moderator variable to explain the endogenous construct, referred to as TPACK.

Table 4. R square and effect size.

	R^2	R^2	Effect Size (f^2)
	Excluded Moderator	Included Moderator	
TPACK	0.729	0.739	0.039

$$f^2 = \frac{R^2 included\ moderator - R^2\ excluded\ moderator}{1 - R^2\ included\ moderator} \quad (1)$$

The pre-test and post-test experiments indicated if the teacher can demonstrate their TPACK, which is convincing to the students with their complementary teaching method. Students are confident with their teachers' proficiency in integrating developed MIS as a complementary teaching method illustrating the subject's concept into online classes.

6. Discussion

The developed MIS was deployed as a complementary teaching method in the online class, and it offers teachers an alternative pedagogy in the virtual classroom. Its developed features were meant to create a fresh experience during the online class in teaching and learning. The freehand writing pad feature allows the teachers to conceptualise the subject taught in the virtual classroom is a plus. With the stated features developed for the proposed MIS, the teachers were proven more efficient when conducting online classes.

Furthermore, the adopted TPACK framework in this paper aimed to evaluate the teachers' pedagogy efficacy with the proposed MIS integrated. Moreover, the constructed proposed model was based on TPACK elements with higher loadings and MIS as the moderator variable. Usually, the TPACK framework is meant for pre-service teachers to make self-assessments on their knowledge from technological, pedagogical, and content perspectives. As for this paper, students' perspective was considered instead of studying TPACK from teachers' perspective. From students' perspective for TPACK, the feedback from students on their teachers' TPACK is more accurate, and fewer misconceptions about teachers' proficiency on TPACK.

Moreover, the developed MIS features integrated into the virtual classroom provide familiarity with the physical classroom environment, assisting teachers in teaching online classes. Thence, TPACK from the student's perspective can provide teachers with better insights about the technology integration in the virtual classroom if teachers can utilise the technology and put it into their teaching pedagogy, delivering the concepts of the subject taught to the students. Additionally, the proficiency and self-efficacy of teachers in teaching using the MIS will affect their TPK and TPACK. It indicates how thorough the teachers understand the technology and integrate it into the virtual classroom creating a better learning experience.

7. Conclusion

The paper illustrates the proposed model with the TPACK framework elements adopted and proposed MIS integrated, highlighting synchronous display and on-screen writing features for the virtual classroom. Introducing MIS features enhances the teaching and learning environment and experience with a better delivery method for teachers delivering their knowledge to the students in the virtual classroom. The

proposed MIS allowed teachers to conduct the online class with features that replicate the familiarity of the physical classroom in the virtual classroom. The proposed MIS integration in the virtual classroom positively affects teachers' TPACK proficiency from students' feedback through the post-TPACK assessment questionnaire distributed to the students when the semester ends. The proposed model was structured with the TPACK framework adoption and the proposed MIS as the moderating effect. Initially, the TPACK framework served as a teachers' self-assessment of their thorough understanding of the three main domains of the framework: TK, PK, and CK. The combination of these domains like TPK, TCK, PCK, and TPACK. However, this paper reveals TK, TPK, and TPACK are significant and have higher loadings for moderator analysis. The constructed model illustrated the elements adopted from the TPACK framework and reflected the teachers' self-efficacy and proficiency in understanding and implementing TPACK when conducting online classes from their students' perspectives with the proposed MIS integrated. The R2 changes 1% due to the inclusion of moderating effect, indicating that MIS was moderating in the relationship between TPK and TPACK, whereas f2 of 0.039 indicated that the moderating effect was significant where TPK*MIS is a vital moderator variable to explain TPACK, which is the endogenous construct. By considering the students' feedback regarding their teachers' TPACK, teachers' misconceptions on their beliefs about their understanding and demonstrating their TPACK were addressed. With the integration of MIS as a complementary teaching method, teachers' delivery method efficacy was enhanced, as illustrated in this paper.

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