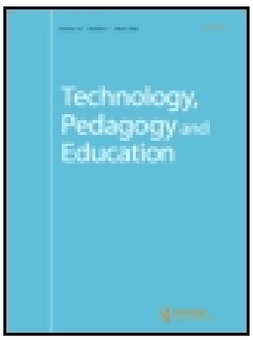

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Continuous mobile devices usage tendency in the TPACK-based classroom and academic performance of university students

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ABSTRACT

This article examines the consequences of routine mobile devices usage tendency in the TPACK-based classroom with the aim of improving academic performance. Findings from the primary data analysis with students and prospective graduates with teaching intention in future (n = 313) in China indicate that the regular usage tendency of mobile devices in the TPACK-based classroom has a significant effect on the academic performance of university students. The effect of routine mobile devices usage has a strong significant relationship among TPACK constructs, continuance intention and academic performance. Despite a few limitations, like small sample size, this article examines the usage of mobile devices in the classroom in such a way that it can help adult learners to improve their academic performance. Also, the article highlights significant paths for instructors, education policy makers and managers of higher educational institutions.

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KEYWORDS
TPACK; mobile device; academic performance; university students; IS continuance theory

1. Introduction

Teaching methods have changed noticeably in the last few decades with the development of modern technology. Smart portable devices and social networks attract learners' attention in the current trend of learning, offering new possibilities (Ooi et al., 2018; Roldan-Alvarez et al., 2018). According to a recent review of the literature from 2007 to 2016, mobile collaborative learning has increased and there is a positive significant connection between collaborative learning and mobile technology (Fu & Hwang, 2018). Another survey across 44 countries found a positive effect of ICT availability in schools but a negative effect of ICT availability at home regarding academic success (Hu et al., 2018). According to a survey in the USA, out of 1439 institutions, 1223 (85%) institutions used educational technology as part of their courses (Kleiner et al., 2007). Different technologies, based on the internet, are extremely popular among young students (Manca & Ranieri, 2013), which has led to some of them becoming addicted to using mobile phone or other portable mobile devices that are capable of accessing 2.8 million Android apps or 2.2 million Apple apps (Singh et al., 2017). Although one survey observed 3+ hours of mobile usage by 71 % US teenagers (Statista, 2017), our daily observations suggest that usage has significantly increased recently. Discussions are common among parents' groups regarding how the younger generation are addicted to mobile device usage and sometimes only concentrate on their mobile phones at public gatherings instead of interacting with others. There is a possibility that social space can be taken over by the excessive usage of mobile phones, which may have a negative effect on our norms and behaviour (Palen et al., 2001). Although

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it seems impossible to reduce the usage of mobile devices, there may be some procedures to enhance the academic performance of university students with regular usage of mobile devices.

The question of how educational institutions can handle the appropriate usage of regular mobile devices to enhance academic performance is the problem addressed by this study. Even though since 2010, after the introduction of Apple's iPad, smart mobile devices have achieved rapid popularity (Papadakis et al., 2018), there has been limited research concerning the usage effects of mobile devices, like the iPad, in the classroom and on digital literacy in a positive way (Crompton & Burke, 2018; Porat et al., 2018; Wakefield et al., 2018); on the contrary, the potential disadvantages of excessive mobile device usage (Felisoni & Godoi, 2018) and multitasking using devices in the class (Waite et al., 2018) have been investigated. The expansion of mobile technology applications in various educational sectors still lacks systematic analysis (Chang et al., 2018). Recent research has suggested improving the quality of online information (Parsazadeh et al., 2018), which may enhance credibility for instructors and learners and encourage them to learn more online with moveable devices. While numerous research works have shown that the usage of mobile devices like notebooks, smartphones, tablets (Hossain, Nurunnabi, et al., 2019; Viswanathan & VanLehn, 2018), laptops, iPads, and pocket PCs provides flexibility and convenience for learning (Aguilar-Roca et al., 2012; Hossain, Shan, et al., 2019; Hossain, Ying, et al., 2019), other studies have shown such usage to be negative due to non-academic usage of the internet in the classroom (Ravizza et al., 2014). However, very few studies have focused on how mobile devices are used in the class (Crompton & Burke, 2018), although recent studies have investigated the usage of mobile devices outside the class (Reychav et al., 2015). Hence, exploring the tendency of routine usage of mobile devices in the class with the aim of assessing its impact on academic performance in a higher educational context is a meaningful research objective. This empirical investigation of the phenomenon intends to contribute to the theory with the development and acceptance of mobile device-assisted teaching and learning methods in the classroom that are further discussed in the following sections.

2. Theoretical framework

The issue of acceptance is not the main focus of information systems (IS) continuance theory (Bhattacherjee, 2001); rather, users' intention to use the technology continuously is the key concern (Figure 1). Recent literature has explored that acceptance and continuance decisions may discontinue at a later stage (Dai et al., 2020) and also explored mobile usage behaviour based on trajectory analysis (Hossain, Xi, et al., 2019) with a focus on (IS) continuance theory (Bhattacherjee, 2001) and expectation confirmation theory (Oliver, 1980) which is similar in this respect as it indicates that satisfaction has a dynamic role in people's increased repeated intention tendency to use technology continuously. According to researchers, innovative strategies are required (Song, 2020) due to repeated tendency, technology addiction, and IT usage behaviour which have a significance influence on personal, work, and social environments (Xu et al., 2011), but the repeated behaviour tendency varies frequently over time and depends greatly on the users' like or dislike of the specific task, which may be for leisure purposes and have no relationship with academic or work purposes. For the last few decades, the usage of technology has been observed to be at a very high level, combined with high TPACK usage tendency among the younger generation and pre-service teachers (Janssen et al., 2019; Oakley, 2020). Technology addiction, unnecessary usage and the overuse of technology have all been recently revealed by researchers (Charlton, 2002; Charlton & Danforth, 2007; Turel et al., 2011).

Technological pedagogical content knowledge (TPACK) may face a challenge regarding the issue of 'technostress', which can be expressed as the overall stress perceived by a person due to necessary usage of technology that he/she is unable to handle or cope with (Tarafdar et al., 2010). This is highly relevant for students because every student has a different capability or tendency for technology usage, either in the class or outside. Environmental or situational factors sometimes generate technology stress, which emerges from technology stressors (Tarafdar et al., 2010,). However, if there is

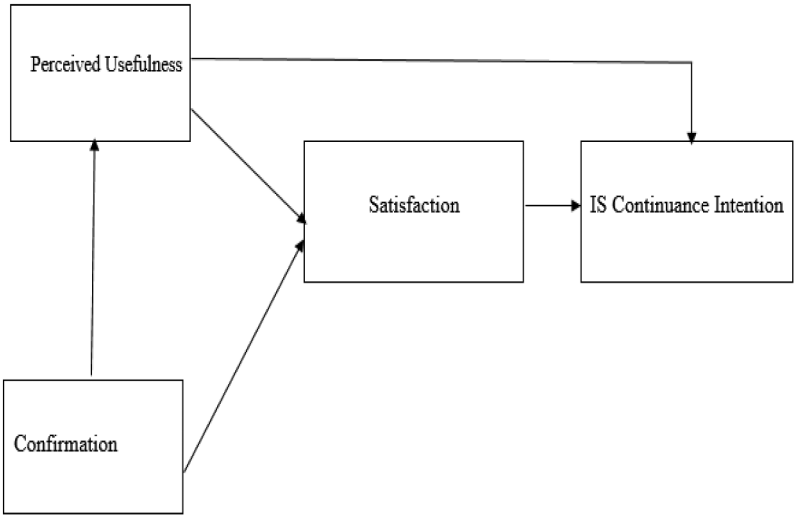

Figure 1. IS continuance theory (Bhattacherjee, 2001).

a continuous tendency to use technology, according to the IS continuance theory (Bhattacherjee, 2001), there is a possibility of satisfaction being derived from its usefulness and applicability.

TPACK is known throughout the educational technology sector as an extension of Lee S. Shulman's significant contribution through the development of the concept of PCK –pedagogical content knowledge (Matthew, 2016). According to the TPACK model, three areas or circles are connected, each containing a different type of knowledge perspective: pedagogical content knowledge (PCK); technological content knowledge (TCK); and technological pedagogical knowledge (TPK). TPACK is essentially a mixture of all these three components as shown in Figure 2 (Tpack.org, 2016). Teaching is an art combined with techniques and methods to explain anything better and make it understandable through an ownership process initiated by the instructor (Admiraal et al., 2015).

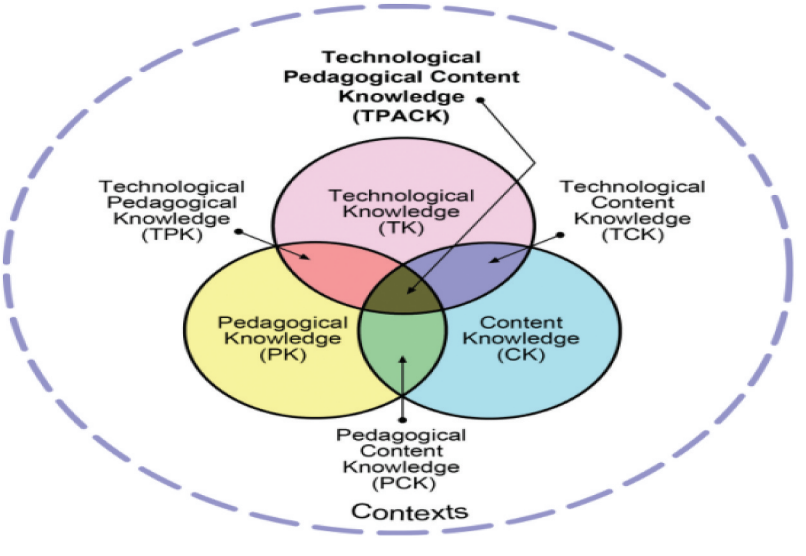

Figure 2. TPACK model (Tpack.org, 2016).

This study focuses on discovering the appropriate usage of mobile devices in the classroom through a routine TPACK structure designed by a course instructor that leads to students not having the opportunity to use mobile devices for hedonic purposes, i.e. mainly focusing on leisure or enjoyment activities such as video games or chatting via Messenger (Venkatesh et al., 2012). It also aims to uncover and combine the various reasons why students use mobile devices in the class for hedonic purposes in order to find how this usage can be converted into utilitarian purposes (Steelman & Soror, 2017), which includes constructive activities. It further explores the suitable usage of mobile devices in the classroom by highlighting: TPACK usage for every lesson (how and why to use it on a regular basis for adult students); and students' mobile devices usage tendency in the classroom.

Even though the usage of mobile devices is widespread, with an increased number of portable computers and internet accessibility as well as numerous methods of teaching and learning using up-to-date technology and apps, the researchers found inconsistent output regarding mobile devices usage (Warschauer et al., 2014). Only a few studies have focused on the usage of mobile devices in an attempt to successfully develop TPACK theory.

3. Research model and hypotheses

3.1. Lesson plans involving mobile technology usage

In the contemporary competitive educational environment, to maintain or maximise the quality of teaching, expert instructors often create lesson plans for specific courses to promote learning (Colliot & Jamet, 2018). Due to differences between courses, a lesson plan may not always include technology usage. Instructors can, however, consider always designing a course outline with the intention of using technology to attract students' attention towards study and deter them from using mobile devices for hedonic purposes. For example, language instructors may not usually think about using mobile devices in the class, but they could use certain apps to improve pronunciation, which would keep students busy in the class with mobile devices, but for utilitarian purposes. This may be considered 'meaningful learning' (Lee & Tsai, 2008), given the practical usage of mobile devices with internet facility. It may also motivate students to learn more effectively, which leads them to use the technology more and gradually become expert in such technology usage. Learning with the support of technology has been appreciated by previous scholars for its ability to facilitate efficient teaching practices (Mayer, 2005).

In some aspects of learning or teaching, there is no alternative to technology, e.g., distance learning (Walker & Fraser, 2005), where students have to use a technological device with internet connectivity. Based on the above discussions, we hypothesise that TCK, technological knowledge (TK) and pedagogical knowledge (PK) are positively impacted by the continuous usage of mobile device usage, with students' academic performance similarly impacted, as follows:

H1: Technological knowledge (TK) acquisition from mobile devices has a positive impact on technological content knowledge (TCK).

H2: Pedagogical knowledge (PK) acquisition from mobile devices has a positive impact on continuous intention (CI).

H3: Pedagogical knowledge (PK) acquisition from mobile devices has a positive impact on technological content knowledge (TCK).

3.2. Unpacking TPACK and academic performance

The basic purpose of TPACK, originally developed by Koehler and Mishra, is to explore a different type of knowledge that teachers need with a special focus on technology (Koehler & Mishra, 2005). It

is an extension of PCK, developed by Shulman, which explores teaching with pedagogy and aims to improve both learning and teaching (Shulman, 1986). According to Koehler and Mishra (2005), effective teaching and learning should be a mixture of TK, PK and CK (see Figure 2).

Although TPACK is not yet widely used, its use has been increasing steadily in the last decade and several research publications have ensued (Wu, 2013). Recently, empirical research has discovered that pre-service teachers need to be exposed to TPACK usage during their training to fully understand TPACK (Angeli & Valanides, 2009). More specifically, first of all, educators should have a clear understanding about the usage of technology, which can make lessons interesting, effective or difficult. Second, based on the subject matter, the lesson should contain precise pedagogical practices to make the learning interesting and effective. Finally, they should create new learning materials based on prior knowledge of their students (Koehler et al., 2013).

TPACK has recently been evaluated as a complex phenomenon (Yeh et al., 2017) because of its integration of different aspects of knowledge as well as individual differences in knowledge (Figure 3). However, measuring educators' PCK has recently been afforded importance because of its ability to facilitate teaching flexibility (Alonzo & Kim, 2015). Angeli and Valanides (2009) further extended the theory, blended with ICT, as 'information communication technology-technological pedagogical content knowledge' (ICT-TPCK). Based on a careful review of the literature, several constructs are associated with TPACK, which we need to unpack:

(1) Technological knowledge: usage of software and digital devices.
(2) Pedagogical knowledge: methods and knowledge on a particular issue.
(3) Content knowledge: knowledge about the specific subject being taught.
(4) Technological pedagogical knowledge (TPK): the means of incorporating technology with knowledge.
(5) Pedagogical content knowledge (PCK): the most useful teaching methods based on the topic or subject.
(6) Technological pedagogical and content knowledge (TPACK): representing a strategic fit between technology and pedagogy for effective teaching (Koehler & Mishra, 2005).

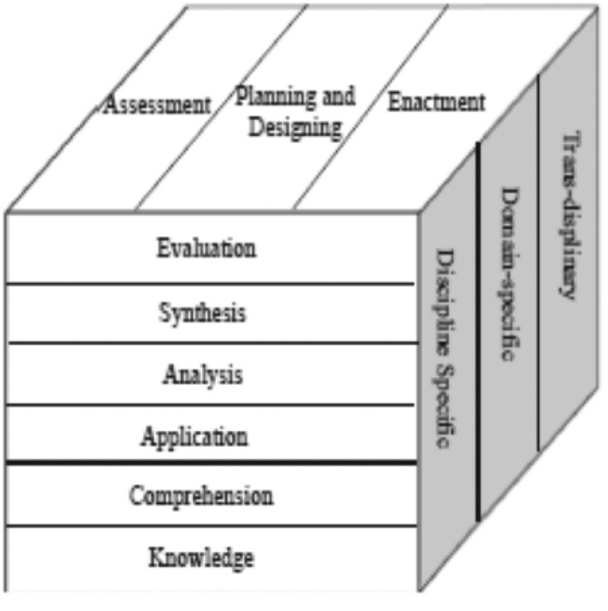

Figure 3. Multiple aspects of TPACK (Koehler et al., 2013).

Academic performance measurement is a complicated phenomenon based on CGPA or marks achieved in various courses. However, recent research includes the lab performance, research and publication ability, extra-curricular activities and innovation in science and technology as well as academic performance (Hossain, Xi, et al., 2019). As a result, recently, effective handling of smartphones is a criterion to measure or predict academic performance. Also, the academic performance varies in terms of various academic arena such as subjects, specialisation and practical performance. For example: the performance of a software engineer may differ from a business administration student. Technological pedagogical and content knowledge assumes academic performance in terms of traditional measurement such as the exam and class performance, class tests, quizzes, assignments and presentations.

Based on the above discussions, we hypothesise:

H4: Pedagogical knowledge (PK) acquisition from mobile devices has a positive relationship with technological pedagogical and content knowledge (TPACK).

H5: Technological pedagogical knowledge (TPK) acquisition from mobile devices has a positive impact on continuous intention (CI).

H6: Technological pedagogical knowledge (TPK) acquisition from mobile devices has a positive impact on technological pedagogical and content knowledge (TPACK).

H7: Technological pedagogical and content knowledge (TPACK) acquisition from mobile devices has a positive impact on academic performance.

3.3. Continuous usage of mobile devices in class and technology-based knowledge sharing

There are numerous mobile devices that have became extremely popular among young students. For example, many young students frequently use tablets or iPads for playing games or social networking purposes. People spend most of their time on strategy, communication, and social activities out of 25 indicators, of which education and navigation usage time were the least observed (Singh et al., 2017). From the survey, it is evident that even though students use mobile devices in the classroom, they use them mostly for hedonic purposes. If that is the scenario then the worldwide initiative to make computer access free (Fleischer, 2012) may have limited benefits regarding development and performance. Lecture-style teaching without the usage of any technological instruments can be observed as an ancient or traditional style of teaching whereas innovating teaching methods have gained in popularity, including cooperative learning (Lan et al., 2007), game-based teaching and learning (Klopfer et al., 2011), practical learning outside the classroom (Liu et al., 2012), verbal learning (Antoniades & Schoeler, 2017), augmented reality learning (Munoz-Cristobal et al., 2018), virtual reality learning, e-learning etc. (Chen et al., 2012).

There remains, however, the question of how many of these innovative technologies instructors encourage students to use, even though technological mobile devices are readily available. If class lectures are designed using TPACK theory, instructors may feel comfortable to encourage students to use mobile devices. Due to the generation gap, conflict may also arise. There are some instructors who may not favour using portable devices in the class at all. Researchers have suggested, however, that high-quality educational media can enhance the cognitive development of students (Jennings et al., 2009). Therefore, it is hypothesised that the usage of technology such as mobile devices in the class positively influences students' academic performance:

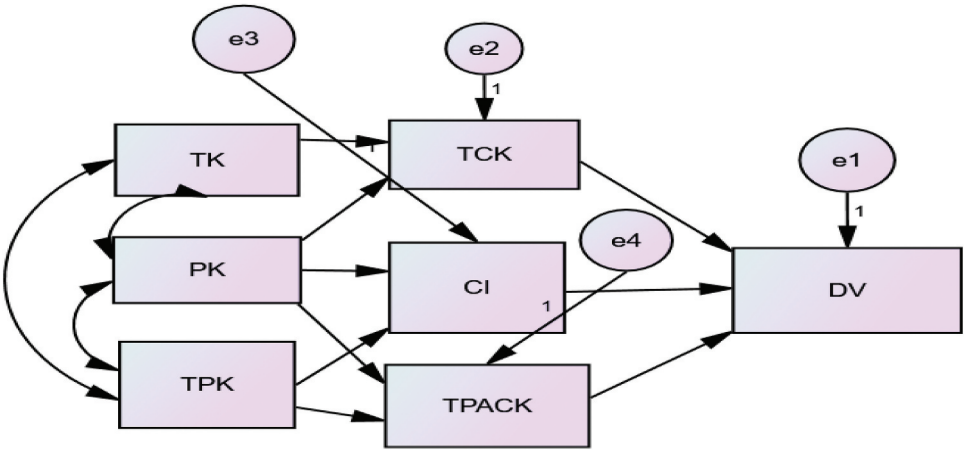

Figure 4. Conceptual research framework.

H8: Continuous intention (CI) of knowledge acquisition from mobile devices has a significant effect on academic performance.

H9: Technological content knowledge (TCK) acquisition from mobile devices has a significant effect on academic performance.

The conceptual model of the research is depicted in Figure 4.

4. Method

4.1. Study context

The study focused on the usage of technology in the classroom with the help of mobile devices in order to fulfill the research aim. To better understand the scenario, the authors decided to create two different course plans based on the TPACK model, in which the usage of technology would be enjoyable and effective in the classroom, along with a standard course plan also based on the TPACK model, but more limited usage of technology (Tables 1 and 2).

4.2. Participants

Participants of this study comprised 313 students from five universities who intend to be a teacher in the near future upon completion of their final year (see Table 3 for the demographic profile). Institutes of Education and Research were targeted by the researchers that provide four-year Bachelor of Education (Hons.) programmes, one-year Master of Education (day) programmes, two-year part-time (evening) Master of Education programmes, MPhil Programmes in Education, and thesis-based PhD. programmes in Education. The respondents were selected based on teaching tendency in the future. We excluded responses for eight students as they were uncertain whether they wanted to become a teacher. The institutions chosen used the latest technology in their classes, so the trainee teacher respondents were assumed to have sufficient technological and pedagogical knowledge.

Participation in this research was voluntary. University authorities and course teachers were contacted and were happy to assist due to the similar nature of their research interests. Participation was not included within the course result to ensure that participants would provide authentic and reliable responses.

Table 1. A class plan based on TPACK with more technology usage intention.

Topic: Referencing methods for writing a journal paper		Duration: 90 minutes
Learning Objectives: End of the session students will be able to: i. Use suitable referencing styles as per the journal requirement. ii. Know referencing usage with different online software.		Number of students: 30–40
Learning Activity (LA)		Activity type
Part 1 (25 + 5 minutes)	LA1. Download sample research from the internet and discuss it in a group of 6 students: Q1. What is referencing and citation? Q2. Why should you learn and use referencing for journal paper writing? Q3. What happens if you do not use references? Q4. Familiar with plagiarism software.	Lecture Group work consists of 6 students in each group
	LA2. Introduction of unique software to use APA referencing style. https://www.citefast.com/?s=APA#_Journal	Independent, referred and practical learning
Part 2 (15 + 15 minutes)	LA3. Download journal paper for free from the university campus. Q1. Know about the accepted list of journals from the university. Q2. Introduce 'author guidelines'. Why is it important? Q3. Writing style according to journal requirement.	Collective work: Group activity consists of 6 members in each group
	LA4. Study in groups of 6 people to analyse the software to recognise resources with internet technology on the referencing approach according to the instructions below: Learn how to use referencing styles in different cases. 1. Group 1: Use the reference building software to create a reference for, and cite in text, a book or journal with one author. 2. Group 2: Use the reference building software to create a reference for, and cite in text, a book or journal with two authors. 3. Group 3: Use the reference building software to create a reference for, and cite in text, a book or journal with three to five authors. 4. Group 4: Use the reference building software to create a reference for, and cite in text, a book or journal with six or more authors.	Collective work: Group activity consists of 6 members in each group
Part 3 (15 minutes)	LA5. Group work to spot the differences among the groups. Learn from each group. Question and answer session in the class. 1. A group member from every group will make a presentation for 2 minutes to introduce others to the referencing style they have learned. 2. Clarification for other group members if they are not clear about the presentation. 3. How is referencing software more useful than manual referencing?	Collective work: Group activity consists of 6 members in each group
Part 4 (10 minutes)	LA6. Exercise time: students are required to use their device to make a list of references. Complete information will be provided.	Independent ability to assess the students
	LA7. Complete an online exercise given in the class on 'citation and referencing – beginning to end'. Students should use any mobile device to access the URL.	
Post-class (5 minutes)	Students' feedback assessment Need for a review class Miscellaneous	Intuitive activity

4.3. Measures

The study used items from Mishra and Koehler's (Chen et al., 2012) Technology, Pedagogy, and Content Knowledge (TPACK) survey. The original TPACK was developed to measure educators' understanding of technology along with pedagogical and content knowledge (Schmidt et al., 2009). The study comprises seven categories, including technology (TK), pedagogical (PK) and content (CK) knowledge. It includes a combination of TPK, TCK and CPK, and a combination of TPACK. As the main purpose of this study is to determine the technological device usage in the class

Table 2. A class plan based on TPACK with less technology usage intention.

Topic: Referencing methods for writing a journal paper		Duration: 90 minutes
Learning Objectives: End of the session students will be able to: i. Use suitable referencing styles as per the journal requirement ii. Know different referencing styles and different ways of referencing.		Number of students: 30–40
Learning Activity (LA)		Activity type
Part 1 (25 + 5 minutes)	LA1. Download sample research from the internet and discuss it in a group of 6 students: Q1. What is referencing and citation? Q2. Why should you learn and use referencing for journal paper writing? Q3. What happens if you do not use reference? Q4. Familiar with plagiarism software	Lecture Group work consists of 6 students in each group
	LA2. Manually write or present the referencing style on the board or show it using PPT Example: Name of author/authors, year of publication, paper topic, Journal name, volume, and issue number, page number, doi, etc.	Independent, referred and practical learning
Part 2 (15 + 15 minutes)	LA3. Download journal paper for free from the university campus. Q1. Know about an accepted list of journals from the university. Q2. Introduce 'author guidelines'. Why is it important? Q3. Writing style according to journal requirement.	Collective work: Group activity consists of 6 members in each group
	LA4. Study in groups of 6 people to analyse the software to recognise resources with internet technology on the referencing approach according to the instruction below: Learn how to use referencing styles in different cases. 1. Group 1: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with one author. 2. Group 2: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with two authors. 3. Group 3: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with Refer three to five authors. 4. Group 4: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with six or more authors.	Collective work: Group activity consists of 6 members in each group
Part 3 (15 minutes)	LA5. Group work to spot the differences among the groups. Learn from each group. Question and answer session in the class. 1. A group member from every group will deliver a lecture for 2 minutes to introduce others the referencing style they have learned 2. Clarification for other group members if they are not clear about the presentation 3. How can manual referencing be improved and made faster?	Collective work: Group activity consists of 6 members in each group
Part 4 (10 minutes)	LA6. Exercise time: students are required to complete a question paper. Answer the following questions: MCQ or open-ended short answer.	Independent ability to assess the students
	LA7. Cross-checking the answers instantly by the students and giving feedback.	
Post class (5 minutes)	Students' feedback assessment Need for a review class Miscellaneous	Intuitive activity

on a regular basis with the intention of improving academic results, the authors finally decided to use 20 items, related to the usage of technology, in seven different categories. Table 3 details the 20 items used for this study. The continuance intention (CI) items are adapted from Wang et al., (2019). The authors decided to use six items in this study. Table 3 details the six items used for continuance intention (CI).

Tables 1 and 2 represent two different course plans based on high or low technology usage intention. There is an issue to divide the students if the teacher decides to select one course plan only. As a result, the instructor may understand the level of the students and decide. On the other

Table 3. Full list of items used in the study.

Category	Item
TK1	I can learn about technology easily.
TK2	I keep up with important new technologies.
TK3	I know about a lot of different technologies.
TK4	I have the technical skills I need to use technology.
PK1	I know how to assess student performance in a classroom.
PK2	I can adapt my teaching based upon what students currently understand or do not understand.
PK3	I can use a wide range of teaching approaches in a classroom setting.
PK4	I know how to organise and maintain classroom management.
TCK	I know about the technologies that I can use for understanding and conducting my subject.
TPK1	I can choose technologies that enhance the teaching approaches within a lesson.
TPK2	I can choose technologies that enhance students' learning for a lesson.
TPK3	My teacher education programme has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
TPK4	I am thinking critically about how to use technology in my classroom.
TPACK	I can teach lessons that appropriately combine my subject, technologies and teaching approaches.
CI1	I intend to continue using my mobile phone in the future.
CI2	I will always try to use my mobile phone in my daily life.
CI3	I plan to continue to use my mobile phone frequently.
CI4	I intend to continue using my mobile phone rather than discontinue its use.
CI5	My intentions are to continue using my mobile phone than use any alternative technology.
CI6	If I could, I would like to continue my use of my mobile phone.

hand, based on the specific scenario such as market turbulence or epidemics such as COVID-19, the instructors may need to depend excessively on the technology usage; for example; designing tools or apps for the students (Prieto et al., 2020).

4.3.1. Technology (TK) measures

Participants' tendency towards technology (TK) measures depended on the usage of mobile technology by researchers for discovery purposes, e.g., how students can learn technology more easily or whether they frequently use technology or not. Participants clearly expressed their view using a 5 point Likert scale with a range of 1 to 5 (1 = *strongly disagree to* 5 = *strongly agree*). Technology factor measurement was averaged to generate a concrete score (Cronbach's $\alpha = 0.81$).

4.3.2. Pedagogical (PK) measures

Participants' tendency towards pedagogical (PK) measures depended on the usage of mobile technology for discovery purposes by the researchers, e.g., how students can be assessed in the classroom or how to organise classroom management. Participants clearly expressed their view using a 5-point Likert scale with a range of 1 to 5 (1 = *strongly disagree to* 5 = *strongly agree*). Pedagogical factor measurement was averaged to generate a concrete score (Cronbach's $\alpha = 0.72$).

4.3.3. Technological content knowledge (TCK) measures

Participants' tendency towards technological content knowledge (TCK) measures depended on the usage of mobile technology for discovery purposes by the researchers, e.g., which technological devices are usable in the class for effective teaching and learning. Participants clearly expressed their view using a 5-point Likert scale with a range of 1 to 5 (1 = *strongly disagree to* 5 = *strongly agree*).

4.3.4. Technological pedagogical knowledge (TPK) measures

Participants' tendency towards technological pedagogical knowledge (TPK) measures depended on the usage of mobile technology for discovery purposes by the researchers, e.g., choosing specific technology for the learners to ensure what they learn and how they learn. Participants clearly expressed their view using a 5-point Likert scale with a range of 1 to 5 (1 = *strongly disagree to* 5 = *strongly agree*). The TPK measurement was averaged to generate a concrete score (Cronbach's $\alpha = 0.78$).

4.3.5. Technology, pedagogy and content knowledge (TPACK) measures

Participants' tendency towards technology, pedagogy, and content knowledge (TPACK) measures depended on the usage of mobile technology for discovery purposes by the researchers, e.g., identifying the combination of teaching with technology, approaches and subjects. Participants clearly expressed their view using a 5-point Likert scale with a range of 1 to 5 (1 = *strongly disagree to* 5 = *strongly agree*).

4.4. Data analysis and results

We analysed data using Mplus version 7.0 by following a two-step approach (Anderson & Gerbing, 1988). First, we conducted a confirmatory factor analysis to measure the reliability and validity of observed data and then estimated the structural model to test the proposed hypotheses.

Cronbach's alpha results for the constructs showed acceptable values from 0.72 to 0.94 (Hair et al., 2006). To better measure the scale reliability (Bagozzi & Yi, 1988), the composite reliability of the items was also measured. As shown in Table 5, the composite reliability values ranged from 0.83 to 0.95, which reconfirms the validity and strong reliability of the constructs (Hair et al., 2006). All necessary items had significant loading values based on respective constructs, and the AVE value showed an acceptable value (greater than 0.50). Thus, the convergent validity of the constructs is fully supported.

4.4.1. Common method bias

Before proceeding to further analyses, we verified that common method bias was not an issue for this study. The issue of common method bias was addressed before data collection and again after data collection. In preparing the participants to take the survey, we clearly stated that there were no right or wrong answers, that their responses were confidential and that they should rate the questions honestly. Then we exposed the collected data to Harman's single-factor test (Podsakoff et al., 2003) and found that a single factor explained only 41.50 % of the variance, which is well under the cut-off criterion of 50 %. Therefore, common method bias is not an issue for this study.

4.4.2. Confirmatory factor analysis

The results of the confirmatory factor analysis are presented in Tables 5 and 6 and indicate the suitability of observed data with the proposed theoretical model. The measurement model was assessed based on criteria recommended by Fornell and Larcker (1981) for model fit indices, reliability, convergent validity and discriminant validity. Model fit indices [chi-square ($\chi 2$/df = 1.815), comparative fit index (CFI = 0.965), Tucker–Lewis index (TLI = 0.959), root mean square error of approximation (RMSEA = 0.051), standardised root mean square residual (SRMR = 0.043)] represent a good model fit. The values for composite reliability (CR) of each multi-item measure were higher than 0.70, which represents high internal consistency among items, while the values of individual factor loadings and average variance extracted (AVE) of all measurement scales were higher than 0.50, providing support for convergent validity (Table 4).

The discriminant validity was assessed by comparison of squared inter-scale correlations with AVE for each construct. The results as shown in Table 6 indicate that discriminant validity was established, as the square root of AVEs (bold values on the diagonal) of all individual scales were higher than their corresponding inter-scale correlations (Fornell & Larcker, 1981; Hair et al., 2006).

4.4.3. Structural model

Model fit indices of the structural model, i.e. chi-square ($\chi 2$/df = 1.988), CFI = 0.948, TLI = 0.939, RMSEA = 0.056, SRMR = 0.053, indicate an acceptable fit as all the values meet cut-off standards (Hair et al., 2006).

Table 4. Participants' characteristics.

Category	Frequency	Percentage
Gender		
Male	198	63
Female	115	37
Age (years)		
18–23	24	8
24–29	148	47
30–35	111	35
36–41	25	8
41+	5	2
Year of study		
Final year	48	15
2nd to 3rd year	143	46
1st year	122	39
Teaching intention		
Yes	313	100
No	0	0
Degree		
PhD student	7	2
Master's student	188	60
Bachelor's student	118	38
Technology usage tendency		
Yes	313	100
No	0	0

Table 5. Confirmatory factor analysis.

Construct	Measurement items	Loadings	AVE	Cronbach's alpha	Composite reliability
TCK	TCK	-	-	-	-
TPACK	TPACK	-	-	-	-
TK	TK1	0.69	0.73	0.81	0.86
	TK2	0.83			
	TK3	0.74			
	TK4	0.65			
PK	PK1	0.57	0.62	0.72	0.83
	PK2	0.64			
	PK3	0.66			
	PK4	0.61			
TPK	TPK1	0.60	0.68	0.78	0.86
	TPK2	0.69			
	TPK3	0.73			
	TPK4	0.71			
CI	CI1	0.87	0.84	0.94	0.95
	CI2	0.88			
	CI3	0.89			
	CI4	0.83			
	CI5	0.80			
	CI6	0.80			

After ensuring the validity and reliability of the constructs, proposed hypotheses were tested with the help of Mplus version 7.0. Table 7 represents the results of the proposed hypothesis testing. Out of nine hypotheses, seven are supported as per the analysis shown below. The results thus demonstrate that different use of knowledge with the help of mobile technology in the class positively effects academic performance.

It is somewhat surprising that the results did not support H1 (TK-TCK) or H6 (TPK-TPACK). The possible reason is that, even though almost all kinds of teaching methods are significantly positive, technological knowledge (TK) is not always relevant to technological content knowledge (TCK), especially in majors like literature, business, or social sciences. A similar reason is suggested for TPK-TPACK. This is because of the variety of the students' learning contents.

Table 6. Correlation matrix and average variance extracted.

Construct	Mean	SD	1	2	3	4	5	6	7	8
TK	3.928	0.76	**0.857**							
PK	3.753	0.71	0.738	**0.790**						
TPK	3.785	0.73	0.722	0.818	**0.828**					
CI	3.678	0.82	0.499	0.620	0.623	**0.918**				
TCK	3.821	0.94	0.448	0.531	0.449	0.334	NA			
TPACK	3.750	0.97	0.442	0.573	0.522	0.374	0.307	NA		
DV	3.447	0.61	0.381	0.469	0.437	0.517	0.471	0.372	NA	

The bold values on the diagonal represent the square root of AVEs.
NA = Not applicable.

Table 7. Statistics of structural model.

Hypothesised path	β	S.E.	C.R.	*p*
TK -> TCK	**0.213**	**0.191**	**1.111**	**0.267**
PK -> TCK	0.795	0.220	3.607	0.000
PK -> TPACK	0.826	0.303	2.725	0.006
PK -> CI	0.529	0.219	2.418	0.016
TPK -> TPACK	**0.277**	**0.264**	**1.046**	**0.296**
TPK-> CI	0.522	0.201	2.603	0.009
TCK -> DV	0.201	0.034	5.895	0.000
TPACK-> DV	0.091	0.033	2.736	0.006
CI -> DV	0.269	0.038	7.103	0.000

R^2 = (TCK = 0.289), (TPACK = 0.337), (CI = 0.425), (DV = 0.384).
Bold values are not significant.

The structural model with results is shown in Figure 5.

5. Discussion and conclusion

In this study, the researchers proposed and empirically tested a model of 'routine mobile usage behaviour with TPACK' in an attempt to enhance academic performance at the university level. Academic performance as a dependent variable was affected by routine mobile device usage tendency in the class. Thus, the results of this study confirm that the usage of mobile devices in

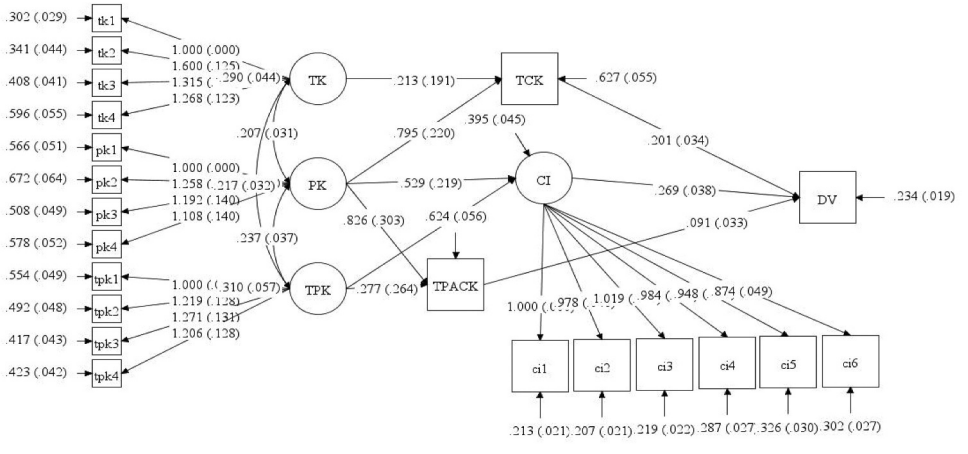

Figure 5. Structural model with results.

the class can enhance the academic performance of the students with the help of TPACK technology. The study added several contributions to the existing literature.

First, the study design incorporated the current literature regarding TPACK and the usage of mobile devices on a regular basis (Hossain, Ying, et al., 2019). It is the first study to develop a research model that examines the utilisation tendency and possible output of mobile devices usage in the class within a TPACK structure. The study filled a research gap on the usage of mobile devices in a positive way rather than stating the potential harm for excessive devices usage (Felisoni & Godoi, 2018) because, in the present situation, reducing the usage of mobile devices is practically impossible to implement, even though digital distraction has been addressed by researchers recently (Wu & Cheng, 2018). The framework showed a unique way to keep the students engaged in the class with their preferred means, because some of the students always use a mobile device in the class for other reasons than academic purposes (Munoz-Cristobal et al., 2018). This framework may contribute to reducing the tendency of mobile usage in the classroom for purposes other than academic needs (Table 8).

Second, the findings of the study enhance existing knowledge regarding flexible study environments combining the usage of mobile technologies on a daily routine basis. The results showed different ways that technology usage can improve academic performance. Academic performance is a complex phenomenon, and graduates are expected to cope with, and navigate, organisational uncertainty (David et al., 2011) using theoretical learning and knowledge; however, in this study, a different learning approach was shown to be more effective in the contemporary study environment. The results make sense because of the involvement of all levels of students in the class due to the usage of mobile technology for academic purposes. It also ensures how educational institutions can enhance appropriate usage of mobile devices to ensure better academic performance.

Finally, most of the previous TPACK research has focused on developing TPACK in the higher educational sector based on using technology efficiently in teaching and learning (Koh et al., 2012) without any possible alternative continuance intention (Hossain, Ying, et al., 2019), while the findings from this research reveal that the implementation of TPACK is an effective approach for adult learners through technology usage with mobile devices on a regular basis, which is consistent with the current literature (Dong et al., 2017). Although the research was conducted in Chinese universities, the research model may be applied in any higher educational setting due to the similar nature of adult learning. Consistent with the empirical result, the authors suggest plan A (Table 1), which offers more technology-based TPACK usage. Notably, during the pandemic situation such as COVID-19, plan A is an undeniably better choice for the teachers and the students.

5.1. Limitations and directions for further research

We acknowledge some limitations in this study, which may contribute to future research. The research used primary data from students with the intention of discovering their perceptions of mobile device usage on a regular basis; however, these respondents all had future teaching intention. We are aware that there are many students who do not have any such intention, although they may change their minds at any time. Future research should investigate TPACK implementation strategy using routine mobile usage in the classroom from actual teachers' perspective as they can better guide researchers regarding academic performance development. Further, the research did not analyse all the TPACK constructs (Koehler et al., 2013), concentrating only on analysing usage tendency and the impact of mobile devices. Future studies should include the usage of multilevel technologies, including the usage of mobile and immobile devices in the classroom. Also, a comparative analysis between teacher and student groups can be investigated to discover user and trainer acceptance tendency towards TPACK implementation with mobile technology usage. Future research also can focus on the different motivational factors that may attract adult learners to accept routine technology usage, regardless of schools, departments or majors. The current research model can be extended with mediating variables such as classroom facilities, students' capability etc.

Table 8. A class plan with TPACK based technology usage intention (The difference).

Topic: Referencing methods for writing a journal paper		Duration: 40 minutes
Learning Objectives: End of the session students will be able to: i. Use suitable referencing styles as per the journal requirement with a video tutorial ii. Know different referencing styles and software with video tutorial		Number of students: 30–40
Learning Activity (LA)		Activity type
Part 1 (25 + 5 minutes)	LA1. Download sample research article from the internet and save in a folder. Q1. What is referencing and citation? Q2. Why should you learn and use referencing for journal paper writing? Q3. What happens if you do not use reference? Q4. Familiar with industry standard plagiarism software with a real example	Lecture in the computer lab or ensure a laptop with every individual student.
	LA2. Present the referencing style on the board or show it using PPT. Example: Name of author/authors, year of publication, paper topic, Journal name, volume, and issue number, page number, doi, etc.	Technology-based independent, referred and practical learning.
Part 2 (15 + 15 minutes)	LA3. Download journal paper for free from the university campus. Q1. Know about an accepted list of journals from the university. Q2. Introduce 'author guidelines'. Why is it important? Q3. Formatting style according to journal requirement with a formatting software.	Individual skill development with software packages
	LA4. Study in groups of 3 students to analyse the software to recognise resources with internet technology on the referencing approach according to the instruction below: Learn how to use referencing styles in different cases. 1. Group 1: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with one author. 2. Group 2: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with two authors. 3. Group 3: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with Refer three to five authors. 4. Group 4: Manually create (without any referencing software) a reference for, and cite in text, a book or journal with six or more authors.	TPACK-based group activity consists of 3 members in each group
Part 3 (15 minutes)	LA5. Group work to spot the differences among the groups. Learn from each group. Question and answer session in the class. Help the students without a portable device. 1. A group member from every group will deliver a lecture for 2 minutes to introduce others the referencing style they have learned 2. Clarification for other group members if they are not clear about the presentation. 3. How can manual referencing be improved and made faster?	Group activity consists of 3 members in each group. Students without carrying a portable device for any reason, could be benefited from sharing with other members.
Part 4 (10 minutes)	LA6. TPACK-based exercise time: students are required to complete a question paper. Answer the following questions: MCQ or open-ended short answer using Google Classroom to ensure learning with a smart technology. LA7. Cross-checking the answers instantly by the students and giving feedback.	Independent ability to assess the students and make the assessment mandatory with Google Classroom to ensure the technology handling capacity of the students.
Post-class (5 minutes)	Students' feedback assessment Need for a review class Miscellaneous	Intuitive activity (need to receive feedback from the students who faced trouble with technology usage such as unable to submit via Google Classroom).

Future research may discover further antecedents and moderating variables using different research methodologies, such as a qualitative approach or focus group interviews. A contrasting experiment may further explore the difference between technology and non-technology based lesson plans. Finally, future research may cross-validate our research framework and discover the implementation impact in university teaching.

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