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Readiness, Technological Knowledge (TK), and Technological Pedagogical Knowledge (TPK) of Teacher Integrating Augmented Reality (AR) Technology During the Teaching Process

Suhana M. Azam, M. Khalid M. Nasir & Hazrati Husnin

Faculty of Education, Universiti Kebangsaan Malaysia (UKM)

Email: sue1528@gmail.com, hazrati@ukm.edu.my

Corresponding Author Email: mdkhalid@ukm.edu.my

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Abstract

Educational practices have changed through the integration of technology in teaching and learning sessions over time. Technology Augmented Reality (AR) has been recognized as a useful resource for learning purposes in improving the quality of teacher teaching and student learning potential. This study was conducted to identify the relationship between the level of readiness, Technological Knowledge (TK), and Technology Pedagogical Knowledge (TPK) teachers in integrating AR technology into teaching. Aspects of TK and TPK are taken from the Technological Pedagogical Content Knowledge (TPACK) theories. A questionnaire was administered to 33 teachers from 8 districts in Terengganu. The study revealed that the mean level of readiness, TK, and TPK among teachers is high. There is also a significant relationship between readiness and TK teachers. The result shows that the integration of AR impacts higher-quality learning without neglecting the importance of textbooks during the teaching process. In conclusion, this study is expected to be used as a useful reference in the research and development of AR for use in teaching and learning process.

Keywords: Teacher Readiness, Technological Knowledge, Technology Pedagogical Knowledge, Augmented Reality

Introduction

The emergence and increased accessibility to digital technology has increased interest in the knowledge required for teachers to effectively apply technology as a teaching aid in the classroom during the teaching process (Dong et al., 2020). In line with the strategic and operational initiatives in the Malaysian Information Communication Technology (ICT) Transformation Plan 2019-2023 (Ministry of Education Malaysia, 2019), the use of ICT and digital capabilities provides students with the required knowledge, higher-order thinking skills, leadership skills, multilingual skills, spirituality, and moral ethics (Malaysia Education Blueprint, 2013-2025).

The integration of Augmented Reality (AR) in the learning and teaching process has been introduced as an effort to meet the future's high-tech workforce characteristics.

Therefore, teachers need to equip themselves with digital technology to face the challenges of 21st century education that emphasizes the latest technology in the teaching and learning process. Teachers and students need to be exposed to adequate ICT skills to enable them to actively engage in learning and teaching process. Teachers need to have skills in using ICT software and applications related to teaching and learning, as well as having knowledge in using more complex technologies such as virtual learning systems (Jang et al., 2021; Nasir, 2020)

Apart from that, the increase in technology in the Industrial Revolution 4.0 (IR 4.0) has provided many opportunities to the use of digital devices and the internet in various environments and contexts (Halili & Sugumaran, 2019). In the context of education, IR 4.0 technology has opened up opportunities to introduce new innovations and more dynamic and fun ways of learning. One of the technologies that incorporates elements of IR 4.0 is AR. Through AR in learning, the Alpha generation (the generation born in the digital age and having access to technology from the beginning of their lives) will be equipped with the skills needed to be critical thinkers, problem solvers, innovators, communicators, and competitive leaders.

The use of technology in learning is very helpful in a more effective learning and teaching process and contributes to a more flexible environment (Ariffin et al., 2020). Bistaman et al (2018) views that technology is the best mode for teaching and learning and has the potential promote more student-centered learning. Meanwhile, Shafeey et al (2021) shows that lack of training and insufficient content are the challenges that impede teachers' effort in integrating AR technology in their teaching process. As the country is in endemic phase, the new norm has created more opportunities to the more widespread use of digital learning (Jafar et al., 2020). Educators are also shifting towards digital teaching and learning platforms in order to enhance the process.

Thus, the shift toward digital platform requires teachers to master digital technology to ensure the successful implementation of their new approach. Progress and technological development are inevitable and imminent, and this serves as a golden opportunity for the teachers to master the new technology. As technology has revolutionized the field of education, teachers should utilize technology wisely in teaching and learning (Raja & Nagasubramani, 2018). The changing world of technological progress should not be seen as a threat but rather as a not to be missed opportunity that should be welcomes with a positive attitude.

AR is a technology that allows users to see the real world around them while adding or simulating artificial objects into the real environment (Nayyar et al., 2018). In the context of education, AR technology can help students understand complex or abstract concepts more easily. Based on the TPACK framework (theory by Mishra & Koehler, 2006), the level of readiness, Technological Knowledge (TK), and Technological Pedagogical Knowledge (TPK) among teachers towards the integration of AR technology is essential to be mastered to ensure efficiency in the use of technology, pedagogy, and related content with the curriculum components.

There is a dearth of research on teachers' readiness to use AR technology, especially in the aspects of TPACK. However, previous studies show that teachers' interest in using textbooks as the main reference in teaching and learning sessions is decreasing with the development of digital textbooks (Mili & Winch, 2019; Singki, 2021). Technology trends in education have changed, and digital elements such as educational games and interactive resources in teaching need to be mastered (Alfiras & Bojiah, 2020). Therefore, the objective

of this study is to determine the teachers' level of readiness, TK, and TPK in integrating AR into the pedagogical methodology by answering the following questions: 1) What is teachers' level of readiness, TK and TPK in using AR technology to deliver lessons in the classroom? 2) Is there a significant relationship between readiness and TK toward AR technology among teachers?

Focus of the Review

Augmented Reality (AR)

Relevant studies in recent years summarize the characterization of AR defining with three elements; a combined reality and virtual environment, extended by interactive imagery of information and running in real-time (Oranç & Küntay, 2019; Garzón & Acevedo, 2019). AR enables better engagement in the learning environment through a unique collaboration of the real and digital worlds (Klimova et al., 2018; Garzón & Acevedo, 2019; Petrov & Atanasova, 2020).

Integration of AR in Various Fields of Education

Suraj (2018) defines AR as a technology that offers a new educational approach to help students develop critical capacity and a deeper understanding of the concepts underlying scientific inquiry. Previous studies prove that AR enables better engagement in the learning environment through the combination of the real and digital worlds offered by AR (Klimova et al., 2018; Garzón & Acevedo, 2019; Petrov & Atanasova, 2020). The contribution of AR has been recognized in various fields including industry and military, travel and tourism, medicine and healthcare, and retail marketing (Perannagari & Chakrabarti, 2019). Various researchers recognize AR as a tool tht provides opportunities to connect the virtual world in the learning environment. AR supports better learning achievement among students in helping teachers to unleash their best practices in teaching and learning sessions (Harun et al., 2020; Ibáñezet al., 2020; Tzima et al., 2019).

According to Sural (2018), the use of AR development technology in education and training activities continues to increase as the education system is more focused on digital education. Hendriyani et al (2019) who evaluated the effectiveness of using AR as an innovative learning medium in the era of Industrial Revolution 4.0 found that teachers were very enthusiastic about using AR in their learning.

Features such as mobility, interaction skills, relevance, and individuality are essential in influencing student learning. Integrating AR technology in teaching and learning can improve these characteristics among students (Perifanou et al., 2022; Hajirasouli & Banihashemi, 2022). Handheld display in using mobile AR such as gamification and simulation for learning technical aspects of machine operation in Technical and Vocational Training (Ismail et al., 2019; Suryanto et al., 2018) and mathematical principles (Bautista et al., 2021).

Apart from that, Al-Imamy (2020) applies AR technology in teaching Arabic to pre-university students by introducing printed texts that combine with digital resources through AR interaction. Results of this study show that the use of AR provided an interactive learning experience that enhanced student performance and level of interest.

Teachers' Readiness to Integrate Technology in Their Teaching Process

Teachers need to be prepared to use technology in teaching by following training (Fauzi et al., 2019; Munusamy & Nordin, 2021). Akyuz (2018); Gan et al (2020) showed that factors such as learning style, level of technology readiness, and group dynamics can affect

learning outcomes in an online collaborative environment (Jamruz & Razali, 2021; Nasir, 2020; Nasir & Ngah, 2022). Apart from that, the Cakir & Korkmaz (2019) study also reported that AR activities designed for Down Syndrome students positively contributed to the increased level of students' readiness, enthusiasm, motivation, confidence, and readiness. Teachers agree that AR teaching materials improve the behavioral development of individuals with cognitive disabilities and speech impairments.

Similarly, Sun et al (2017) found a significant influence on teachers' readiness to use technology in the classroom through proper training and support. Apak and Taat (2018) meanwhile agree that the use of technology is increasingly needed in the era of Industrial Revolution 4.0. Teachers' high readiness to apply technology in teaching can help produce more creative, innovative, and highly skilled students who can compete in the current and future labor market.

Jwaifell (2019) also revealed changes in the readiness of science teachers to integrate AR into teaching. The view of teachers in applying new technology to learning patterns is fundamental because they are direct users of the technology (Gargrish et al., 2021). Teachers need to be given a space to provide feedback and criticism for the surplus and lack of technology so that future improvements and customization can be made better. In ongoing learning, teachers must also be trained periodically to ensure they are skilled with the new technology in education. Nordin & Daud (2020) studied the standard level of early high school student's readiness on the AR science textbook and found that the level of second-grade students' acceptance of using AR textbooks was at a high level.

Technology knowledge (TK) and Technological pedagogical knowledge (TPK)

The TPACK model (Koehler et al., 2013; Mishra & Koehler, 2006) is one of the most influential frameworks for technology integration in education. Furthermore, TPACK has also received the highest recognition from various studies as a practical framework for identifying teachers' knowledge about technology (Fragkaki et al., 2020; Belda et al., 2022). The TPACK model combines three main dimensions, Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) to form TPACK knowledge that reflects the integration between the three dimensions in the context of learning and teaching. TK is defined as using computer technology and manipulating programs to produce the desired results for teaching and learning sessions (Kim, 2018; Hämäläinen et al., 2021; Seufert et. al., 2021). Whereas TPK is defined as a general pedagogical strategy to apply technology in education. The ability to understand the applications of technology can transform the creative style of teaching (Kim, 2018; Hämäläinen et al., 2021; Seufert et. al., 2021). This model also considers factors such as the level of technology skills of teachers and the needs of students to enable teachers to plan and implement effective teaching using technology.

A study by Gan et al (2020) concluded that TPACK can effectively integrate educational ideas with information technology and promote better-quality teaching approaches. In addition, the intersection of knowledge is confirmed in TPACK as a productive framework for integrating technology to advance content understanding among teachers and students (Shafie et al., 2019; Galanti et al., 2020; Widyasari et al., 2022b). Therefore, further research can be expanded and improved to consider regional, cultural, and classroom environmental differences, due to the characteristics of TPACK that are generally influenced by teacher readiness factors. In TPACK elements, this study only focusses on two elements, namely Technological Knowledge and Technological Pedagogical Knowledge to be used in the implementation of the study.

Methodology

Research Design

The study is survey research and employed descriptive and correlational research design. It uses a quantitative approach using questionnaires to collect and obtain information related to the research questions. The questionnaire survey is suitable for examining the relationship between the level of readiness, TK, and TPK of teachers using AR technology towards the digital education shift.

Sample

The study sample consists of teachers who were appointed as *Guru Penyelaras Bestari* (GPB) according to *Surat Pekeliling Ikhtisas Bil. 3/2005* (Ministry of Education Malaysia, 2005) and served in several primary and secondary schools in the State of Terengganu. Purposive sampling involved 33 GPB teachers from eight districts. The respondents were selected based on their attendance at the *Bengkel Pembangunan Aplikasi* organized by the *Sektor Sumber dan Teknologi Pendidikan* (SSTP), Terengganu State Education Department.

Instrument

The instrument to measure teachers' readiness in this study was adapted from (Fauzi et al., 2019). For Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK), an adaptive instrument of Schmid et al (2020) was used with some amendments to ensure that the item aligns with the scope of this study. This questionnaire contains 20 questions divided into four sections. Part A contains the demographics of the respondents; Part B measures teachers' readiness for AR technology; Part B relates to teachers' TK of AR technology, and Part D relates to teachers' TPK of AR. Table 1 shows the details of 20 variables. A five-point Likert scale is used in this study, where respondents are given five answer options, from 1-Strongly Disagree to 5-Strongly Agree, for each question in the questionnaire. Online questionnaires were used to save time and cost.

Table 1
Variables

Section	Construct	Number of items
A	Demographic	2
B	Readiness	8
C	Technological Knowledge (TK)	5
D	Technological Pedagogical Knowledge (TPK)	5

Data Analysis

Quantitative data were analyzed descriptively using SPSS software version 26 involving frequency, percentage, mean score, standard deviation, and mean score interpretation. The data is translated according to the interpretation of (Mansor et.al., 2021). Meanwhile, the relationship between readiness and TK towards AR technology among teachers and the relationship between readiness and TPK towards AR technology among teachers were analyzed using the Pearson correlation test.

Validity and Reliability

A pilot study was conducted on 10 teachers with an ICT background to determine the validity and reliability of the instrument (Omar, 2021). Based on the findings of the pilot study, the overall reliability of the instrument recorded a high Cronbach's Alpha (α) coefficient with a value of, α = 0.960, indicating that this study has a high level of consistency (Bond, 2015). The value of the three constructs, namely Readiness, Technological Knowledge (TK), and Technological Pedagogical Knowledge (TPK), shows the value alpha exceeds 0.7 which is 0.911, 0.933, and 0.927 each.

Findings

Respondent Demographic Information

The majority of respondents are female teachers, 75.8%, while male teachers are 24.2%. Of the number of teachers, 33.3% indicated that they had more than 20 years of teaching experience, followed by 45.5% with 11-20 years of teaching experience. In comparison, 21.2% of teachers have less than 10 years of teaching experience. The result shows that the number of teachers who have experience using AR or are familiar with AR is equivalent.

Level of teacher readiness, Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK) using AR technology to deliver lessons in the classroom

The overall level of teachers' readiness to use AR in teaching and its components is high. The overall mean score is M = 3.79 (SD = 0.350). Based on the mean score, the level of teachers' readiness to use AR technology in teaching is still high. Thus, it indicates that the majority of respondents are willing to use AR technology in teaching and learning. Meanwhile, the average mean score of the level of TK of teachers using AR technology to deliver lessons in class is at a high level of 3.61 (sd 0.526). The level of TPK using AR technology to deliver lessons in class is also high with a mean score of 4.33 (sd 0.549). The data is summarized in Table 2.

Table 2
Construct level of readiness, TK and TPK

Construct	Mean (*M*)	Standard Deviation (*SD*)	Skewness	Level
Readiness	3.79	0.350	-0.256	High
Technological Knowledge (TK)	3.61	0.526	-0.134	High
Technology Pedagogical Knowledge (TPK)	4.33	0.549	0.785	Very High

A significant relationship between readiness and TK towards AR technology among teachers

The strength of the relationship between the variables is measured based on the value of the correlation coefficient, *r* obtained. Value interpretation by Dancey & Reidy (2020) is used as a reference. The relationship between readiness and TK teachers toward AR technology was tested. Data proved to be normally distributed, Pearson's correlation test was used, r (32) = .31, p <.05. This means that 31% of the variance in the level of readiness can be expected from TPK teachers to integrate AR technology in teaching.

A Significant Relationship Between Readiness And Tpk Toward Ar Technology Among Teachers

The relationship between teachers' readiness and TPK towards AR technology was tested. The TPK variable is normally distributed, and therefore the Pearson correlation test was used in this study. The result found that the relationship between readiness with Technology Pedagogical Knowledge of AR technology among teachers is not significant.

Discussion

The results obtained through an online questionnaire survey aimed to identify teachers' readiness for integrating AR in teaching in the classroom. Therefore, it is organized according to the dimensions of the TPACK model chosen by the researcher i.e., TK, and TPK. The teacher readiness level of integrating AR into the teaching process is high. The findings of this study have similarities with the study of Stojšić et al (2019); Scherer et al (2021); Spiteri & Rundgren (2020) related to the readiness of teachers to integrate immersive technology using mobile devices in the classroom. However, the finding of the study by Asbulah et al (2022) about the readiness of knowledge using AR in Arabic was found at a moderate level. Teachers' findings on Technology Knowledge explain their familiarity with AR technology and their existing knowledge that may help apply AR in learning. The results show that teachers consider themselves sufficiently knowledgeable about AR technology and capable of learning more about AR. However, only a small percentage showed a lack of experience using AR in the classroom. Overall, most teachers dominated the questionnaire by expressing their good level of knowledge and high skills to handle AR technology.

It was found that teachers have the sufficient TK to be combined with appropriate pedagogical approaches for better teaching quality in learning. Thus, teachers need to apply TK, skills, and good attitudes to use technology effectively. As described by Fragkaki et al. (2020), Technological Pedagogy Knowledge is an exogenous domain in TPACK that should be focused on because it incorporates two essential knowledge needed for better technological integration in the teaching process.

Conclusion

In conclusion, the level of readiness of teachers to use Augmented Reality (AR) in teaching is high and there is a significant positive relationship between readiness and technology knowledge to use AR in teaching. Teachers in this situation are ready if the Malaysian Ministry of Education decides to implement AR in teaching and learning because they have a high level of readiness, technological knowledge and technological pedagogical knowledge. It can be said that teachers who participated in this study are open to new ideas in their teaching, especially in integrating AR in teaching process because they recognise the potential benefit. The findings of this research paper put forth the position that teachers are indeed ready to use technology that makes teaching fun and interactive.

Additionally, the results of the readiness, Technological Knowledge and Technological Pedagogical Knowledge in TPACK show a high self-perception among the participants which can be explained by the fact that the more specific the knowledge, the higher the need to practice holistically approach. In other words, TK and TPK among teachers towards the integration of AR technology is important to be mastered to ensure the efficiency of the use of technology, pedagogy, and content related curriculum components as shown by (Mishra and Koehler, 2006). This is because teachers often lack the necessary media teaching skills

(Shafeey et al., 2020). Apart from that, correlation analysis shows that teachers with higher technological knowledge find the use of AR integration easier in the teaching process. This again emphasizes the need for better technology and pedagogy preparation among educators in the future. In other words, teachers easily learn the technological knowledge (TK) related to various tools (AR), but hesitate about the most appropriate pedagogical methods to integrate them (constructivism, connectivism) into the classroom.

However, there is no correlation between teacher readiness and technological pedagogical knowledge (TPK) and this shows that there is a need to prepare future teachers with better training in digital oriented methods through the application of constructivist learning and situated learning theory so that they can learn how to use technology which are different to effectively integrate AR into teaching. Therefore, a positive attitude, proper training on modern pedagogic methods can be considered a key factor for a meaningful integration of AR in the classroom. Teacher training programs need to be updated to include practical training in AR technology, not only for content delivery but also for knowledge transformation through the use of AR. Then, a holistic approach is needed for the effective integration of AR technology in education, covering both technological and pedagogical aspects.

A continuing professional development initiative should be carefully designed and offered to all teachers at all levels and for every subject. Teacher education programs need to incorporate TK and TPK elements into their curriculum to develop relevant teacher teaching skills. Teachers should be provided with materials, resources, and professional development opportunities to keep pace with new demands to integrate technology into the classroom. Therefore, the conclusions that can be drawn from this study are summarized in Table 3 below

Table 3
Conclusion

Conclusion	Importance/Significance
High readiness of participants in the two main sections (TK and TPK)	By incorporating these elements (TK and TPK) into teacher training programs, educators can increase the readiness of teachers to integrate AR effectively in their teaching practices. It emphasizes an understanding of how technology and pedagogy interact and influence each other to improve teaching and learning.
Correlational Analysis	Analysis shows that teachers with high technology skills find AR integration easier in the classroom. It emphasizes the need for better technology and pedagogy preparation among future educators. Teachers' readiness for AR appears to be a predictor of their perception and mastery of AR technology for content creation and visualization.
Teacher training programs	Teacher training programs play a pivotal role in equipping educators with the necessary skills and knowledge to integrate AR effectively into their teaching. Teacher training programs need to be updated to include hands-on training in AR technology for knowledge transformation through the use of different types of AR, not just content delivery. This prepares teachers to design and implement meaningful AR experiences that support student learning in diverse and engaging ways.

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