

Exploring the Effect of Science Teachers' Age Group on Technological Knowledge, Technological Content and Pedagogical Knowledge in Augmented Reality

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ABSTRACT

This study describes the effect of science teachers' cognizance of technological knowledge, technological content, and pedagogical knowledge towards augmented reality across five age groups. This pilot study involved 44 science teachers from Penang, Malaysia using a 5-point Likert scale instrument. The administered survey instruments consisted of 18 questions on technological knowledge; technological content knowledge; and technological pedagogical knowledge. The analyses showed that generally teachers had good technical knowledge but their technological content and pedagogical knowledge seemed to be less. The results also showed that two items had significant differences using the Kruskal Wallis non-parametric test. The findings would be used as a tool to revise the servicing teachers' technological practices using augmented reality incorporated in their daily teaching and learning sessions to obtain better learning outcomes. The research findings could also be used for further research exploring other variables affecting teachers' technological knowledge. The intervention may be used in teachers' training curriculum and continuing professional development in terms of determining their level of technological content and pedagogical knowledge that would increase the interest of students in learning and exploring science using Augmented Reality

Keywords: Augmented Reality, Pedagogical Knowledge, Science, Technological Content Knowledge, Technological Pedagogical Knowledge Technological Knowledge

INTRODUCTION

Background of the Survey Study

Technology has become embedded in education and the results indicate positive impacts on teaching and learning processes in a classroom [1]. Lessons that are supported by technology will lead to more innovative forms of teaching and learning [2]. This is because the use of technology comprises solutions to real-world problems, dissemination of current informational resources, active simulations of concepts, and continuous communication with professionals in the field. Learning to use technology is believed to complement the traditional forms of pedagogical methods [3]. Aligned with the use of technology and pedagogy, the purpose of this study is then to explore science teachers' Technological Pedagogical and Content Knowledge (TPACK) on the use of Technology Enhanced Learning in science education. It is known that the integration of technology in the classroom enhances students' grasping of science concepts worldwide and local.

Generally, teachers are known as curriculum implementers in a school setting.

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Therefore, teachers not only have to adapt and well-equipped themselves with pedagogy and content skills but also digital skills in order to integrate the use of technology in a classroom. According to [4], the integration of technology will provide a means to enhance students' learning and engagement in a classroom. Especially, during the Covid-19 pandemic, the learning and engagement may be compromised.

Rationale of the Study

Science and mathematics are considered core subjects in the school curriculum and are considered the base disciplines of Science, Technology Engineering and Mathematics (STEM) education at the basic education level. Most countries across the world have given priority to the understanding of scientific knowledge and practices in their national education programs to enhance science education. The incorporation of technology may enhance science teaching in classrooms appear to be more exciting amidst popular belief that science is a boring subject. The incorporation of new approaches such as technology brings about new challenges and difficulties. Some of these challenges affect teachers' style of teaching and students learning practice. Technology now could not be sidelined in the learning of science and it is belief the older generation of teachers will be most affected by this incorporation of technology.

Along this vein, a number of questions linger in the minds of science teachers as to how using technology may enhance the teaching and learning of science. One of the questions raised is the frequency of technology especially technology in augmented reality in science classrooms focusing on the age of educators.

The Aims of the Study

This study is then on teachers age group technological knowledge towards a specific area i.e., augmented reality and its effects on technological knowledge (TK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK).

Research Questions

The following are the research questions for this study:

1. Does a specific science educators' age group positively inclined to use augmented reality?
2. What are teachers' perceptions of technology in the science classroom?

Hypotheses for this study include:

1. Teachers' age group between 31-35 experience higher levels of augmented reality use in science classrooms
2. Younger teachers (36-40) age groups experience higher technological knowledge
3. Younger teachers (31-35) age groups experience higher technological pedagogical knowledge
4. Teachers' age group of 31-35 experience higher technological content knowledge than other groups.

Significance of the Study

This study proposed to gather information on teachers' age group in the use of Augmented Reality on technological knowledge (TK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK). The relevant age groups information is

important to evaluate how the age category has (if any) effect on the three variables. The findings could offer insights on the extent to which the students have shown positive attitudes based on their perceived agreements on the specific items under the three domains captured in the survey questionnaire.

Likewise, the findings would be used as a tool to revisit or re-look at the national science curriculum of the participating countries in terms of content standards as well as suggested pedagogies by their respective curriculum makers. Findings would also inform teachers of how teaching and learning practices could be better aligned with students' thinking, attitudes, and perceptions in order to obtain better learning outcomes. Finally, the findings could serve as an eye-opener and input for teachers' continuing professional development in terms of technological pedagogical content knowledge (TPACK) of the science topics which students find very interesting and the corresponding curriculum development of appropriate instructional materials in various modalities (i.e., digital, videos, flipped classroom, simulations, slide shows, CD rooms, blogs, or printed copies).

Literature Review

The word 'technology' was derived from the Indo-European word 'tek' which means the building of wooden houses while the Greeks used the term *techne* meaning how things were made in the fifteenth century. In the eighteenth century, the term 'technologie' was used in German academics and by the nineteenth century the word *technologie* evolved into *technology*, with the use of the word *technology* first used in Massachusetts Institute of Technology in the 1850s making way to the more popular use of the term [5]. Gradually, technologies are incorporated into many aspects of human life including the education field giving rise to a new discipline of technology education. Technology education then refers to the integration of technology in education which is now a central tool in developing or communicating science concepts more efficiently to students. A few studies have shown that the integration of technology and face to face instructions may augment the students' engagement [4][6].

Technological knowledge (TK), technological in pedagogical knowledge (TPK) and technological in content knowledge (TCK) are termed essential in any science classroom incorporating technology. The three components are extracted from the TPACK model as the model involves four other components comprising of content knowledge (CK), pedagogical knowledge (PK), pedagogical and content knowledge (PCK) and technological pedagogical and content knowledge (TPACK). Assimilating technologies with subject content knowledge and pedagogy is thus essential in assisting students' grasping of particularly, science knowledge in schools [7]. The TPACK framework builds on Shulman's construct of Pedagogical Content Knowledge (PCK) encompassing the integration of technology in the teaching and learning process [8].

Technology has become embedded in education and the results indicate positive impacts on teaching and learning processes in a classroom [1]. Lessons that are supported by technology will lead to more innovative forms of teaching and learning [2]. Other studies supporting the strength of technology have shown the importance of integrating technology and face to face instructions may augment students' engagement in their learning [4][6]. The use of technology in the education sector especially in public schools is inevitable, aligned with 21st-century learning encompassing attitudes, and aspirations in line with the global wave of modernization in education [9]. They elaborated that in Malaysia the use of technology in education started in 1997 as part of the Multimedia Super Corridor's Flagship

Applications with the introduction of a smart school project, implemented to develop and equip students with skills to face challenges of the 21st century before entering the workforce. Parallel with this, the government came to realize its importance and heavily invested in the 1BestariNet initiative via a learning management system called the Frog Virtual Learning Environment (VLE) that could bridge thousands of primary and secondary schools in Malaysia in a cloud-based platform later. Since 1997, the use of technology increased and a study by revealed that 76 % of schools in Malaysia use technology for education, 57% of teachers in Malaysia use technology for education and 72% of students in Malaysia use technology for education [10].

The numbers indicated that Malaysian schools have integrated the use of technology in education but their use in schools remains low. Ebrahimi & Jiar also uncovered that an average of 2 minutes 46 seconds per hour use of technology in secondary schools is quite worrying as opposed to an increasing trend use of technologies globally [10]. Therefore, the advancement in technologies was necessary to meet the increasing trend and coherently increase a higher demand for the use of various technologies in Malaysia's education environment.

However, the percentage of success in the learning of science is dependent on the level of educators' technological expertise. Learning to use technology is believed to complement the traditional forms of pedagogical methods [3]. It is known that the integration of technology in the classroom enhances students' grasping of science concepts worldwide and local. The level of teachers' level of technology may pose some difficulties especially when we categorize teachers with levels and factors related to it. A review by Malik et al., identified knowledge of technology alone does not reveal effective technology integration in learning. Malik et al. argued that content and pedagogy skills are also important in ensuring a successful teaching and learning session [11]. In contrast, another study by Young et al. characterized pre-service teachers have a stable foundation and being able to integrate knowledge and skills with technology [12]. Educators were seen to reveal certain traits or attributes when running online classes.

The use of more advanced technology including mobile technologies seemed to affect teachers' technological skills and may pose more challenges. Mobile technologies are growing fast in education. These technologies including Virtual reality (VR), Augmented Reality, (AR) and 3D applications are said to be significant technologies in years to come. Augmented reality (AR) is a technology with great potential for use in education [13][14]. This technology is an expansion of Virtual Reality (VR) that allows a combination of real-world with virtual objects imposed on real-world objects [15]. A number of AR android applications include HP reveal, Cospaces Edu, Wonderscope, Google Expeditions, Metaverse, and Snapchat. Researchers in science learning have revealed many misconceptions that students hold. Using AR technology teachers now have a way to address these alternative conceptions effectively. One alternative conception that was successfully removed using AR is the concept of pressure. Students often thought drinking through a straw is an act of pulling or sucking instead of the differential inside and outside of the resulting pressure. A study was done with Grade 6 through 8 (11-14 years old) students in America by consisting of 29 students not using AR as opposed to 43 students using this technology were able to replace the alternative conception with a correct conception of the Bernoulli's principle, indicating a significant difference in using AR technology [16]. A review and analysis study by Garzon et al., evidently showed the three

main advantages of using augmented reality are learning gains, motivation and abstract concepts [17]. Students were found to increase their academic performance when using AR. Motivation levels were revealed to be higher when learning AR possibly caused by the high use of sensory engagement during the teaching and learning process [18].

The evidence above shows the importance of incorporating augmented reality in a science classroom. Teachers managing this science classroom are advised to amalgamate technologies with their pedagogy and content knowledge. Many of these teachers have been in service for many years and a minority of them started teaching well into the term of five years below. Thus, do these senior teachers equip themselves with relevant technologies? In the position of Rana, observed that the younger age group scored lower than the middle age group [19]. However, no significant differences emerged among younger, middle and older age groups. Narrowing the gap across age groups may be the way forward but is not a common trend. For example, in Norway, 77% of teachers who are 25 years or younger stated to possess a good command of technology skills compared to 25% of 56 years old teachers [20].

MATERIAL AND METHODS

Research Design

The purpose of this study was to describe the technological instances towards augmented reality based on age groups. Online surveys distributed using google forms was developed with a focus on gaining an understanding of teachers' age using technology in augmented reality.

The Research Instrument

The survey questionnaire was developed by the researcher based on adaptation and modification of the past surveys found in a number of studies [14][21][22]. The 15-minute survey was distributed through a workshop attended by participants. The survey only targeted workshop attendees who were keen to learn about augmented reality.

Content Validation

The survey instrument included 41 questions requesting a five-point Likert scale response where 1 strongly disagreed and 5 was strongly agreed. Age groups were banded that increased the statistical power for non-parametric statistical analysis. T-test approaches were performed on the responses to Likert scale statements within SPSS to determine if a significant difference existed between different age groups. As responses to the Likert scale were not assumed to be normally distributed the non-parametric Kruskal-Wallis test was considered as an appropriate statistical test [23]. A posthoc analysis of the results of the Kruskal- Wallis tests was then undertaken using Dunn's multiple comparison test. An average Cronbach alpha coefficient of 0.912 displaying high reliability of internal consistency coefficient was registered.

The Participants

The sample participants were selected from attendees of a workshop conducted. The participants comprised science teachers in Penang from different age groups totalling 45 respondents and 16 schools.

Survey Administration

The survey items were administered online via Google Form before the workshop. The survey links were shared two weeks before the workshop.

RESULTS AND DISCUSSION

Data Analysis

The quantitative analysis for this study used SPSS Statistical Package to obtain percentages and means. A mean of 2.5 is considered neutral with means greater than 3.0 being positive and means less than 3.0 as less positive. Frequencies were calculated for a set of Likert-style statements, with a 5-point scale. In the presentation of the results, the percentages of *strongly agree* and *agree* responses were combined or collapsed.

Teachers' Age Group towards Technological Knowledge in Augmented Reality

To determine the teacher's age towards technological knowledge, the responses of teachers were tabulated and analysed with SPSS. The total mean score and percentage of strongly agree/agree have been summarised in Table 1.

Table 1. Summary of Percentage Agreement and Mean on Teachers Technological Knowledge

Items	Participating Educators age (Percentage of Strongly agree/ Agree and Mean)					Ave %	p-value
	31-35	36-40	41-45	46-50	More than 50 years		
I know how to use a smartphone	100.0 (4.67)	100.0 (4.65)	100.0 (4.30)	100.0 (4.50)	100.0 (4.17)	100 (4.46)	0.183
I know how to use a tablet	100 (4.56)	94.1 (4.59)	90.00 (4.30)	50.00 (4.50)	33.33 (4.17)	73.49 (4.42)	*0.009
I know how to download AR applications	77.77 (3.89)	58.8 (3.71)	50.00 (3.2)0	50.00 (3.50)	66.67 (3.67)	60.65 (3.59)	0.649
I know how to install AR applications	77.77 (3.78)	58.8 (3.71)	40.00 (3.10)	50.00 (3.50)	33.33 (3.17)	52.00 (3.45)	0.439
I know how to use AR applications	44.4 (3.22)	52.94 (3.53)	10.00 (2.50)	50.00 (3.50)	33.33 (3.17)	38.13 (3.18)	0.194
Mean Average	79.99 (4.02)	72.93 (4.04)	58.00 (3.48)	60.00 (3.90)	53.33 (3.67)	64.85 (3.82)	

Note: Means are shown in brackets

Results revealed the age mean value 3.82 indicating highly positive towards technology but items with AR questions seemed to display less positive interest. The lowest average value was registered for item "I know how to use AR applications" with only 64.85%. The age group of 41-45 was the least positive on AR and the most positive were derived from the age group 36-40. For item "I know how to use a tablet" revealed a significant value in this subscale of technological knowledge.

Teachers' Age Group towards Technological Content Knowledge in Augmented Reality

To determine the teacher's age towards technological content knowledge, responses of teachers were tabulated and analysed with SPSS. The total mean score and percentage of strongly agree/agree have been summarised in Table 2.

Table 2. Summary of Teachers' Technological Content Knowledge in Augmented Reality Based on Strongly Agree and Agree Responses in Percentages, and Means by Age Group

Items	Participating Educators age (Percentage of Strongly agree/ Agree and Mean)					Average	p-value
	31-35	36-40	41-45	46-50	More than 50 years	% mean	
I know AR applications that could enhance students' science understanding	44.44 (3.44)	58.82 (3.59)	40.00 (3.20)	50.00 (3.50)	66.67 (3.33)	51.99 (3.41)	0.488
I know about AR applications for doing science	44.44 (3.33)	52.94 (3.47)	20.00 (2.90)	50.00 (3.50)	66.67 (3.50)	46.81 (3.34)	0.491
I know about AR applications to show specific science concepts	44.44 (3.33)	58.82 (3.47)	20.00 (2.90)	50.00 (3.50)	66.67 (3.50)	47.99 (3.34)	0.286
I know about AR applications to deliver learning instructions	55.55 (3.44)	58.82 (3.47)	30.00 (3.20)	50.00 (3.50)	50.00 (3.33)	48.87 (3.39)	0.901
I know how to use AR applications in science textbooks	55.55 (3.33)	58.82 (3.41)	30.00 (3.00)	50.00 (3.50)	50.003 (3.50)	48.87 (3.35)	0.748
I know how to use AR applications for students to view objects in science classrooms	66.67 (3.44)	58.82 (3.53)	10.00 (2.70)	50.00 (3.50)	33.33 (3.17)	43.76 (3.27)	0.192
Mean Average	51.85 (3.39)	57.84 (3.49)	25.00 (2.98)	50.00 (3.50)	55.56 (3.39)	48.05 (3.35)	

Table 2 displayed a mean value of 3.35 indicating moderately positive of using AR content knowledge. The data revealed teachers' use of technological content knowledge in augmented reality is less than their technological knowledge.

Teachers' Age Group towards Technological Pedagogical Knowledge in Augmented Reality

To determine the teacher's age towards technological pedagogical knowledge, responses of teachers were summarised in Table 3 that displayed the average mean value of 3.33 or 43.36% indicating a moderate positivity interest in AR. The data revealed teachers' use of technological content knowledge in augmented reality is slightly lower than their technological knowledge but almost the same with their technological content knowledge. A significant difference was exhibited in the item "I prefer to use AR applications in my teaching".

Table 3. Summary of Teachers' Technological Content Knowledge in Augmented Reality Based on Strongly Agree and Agree Responses in Percentages, and Means by Age Group

Items	Participating Educators age (Percentage of Strongly agree/ Agree and Mean)					Ave-rage	p-value
	31-35	36-40	41-45	46-50	More than 50 years	% mean	
I use AR applications to enhance my pedagogical skills	33.33 (3.00)	64.70 (3.53)	0.00 (3.20)	50.00 (3.50)	50.00 (3.33)	39.61 (3.31)	0.107
I use AR applications to create students' interest before starting a lesson	33.33 (3.00)	47.05 (3.29)	0.00 (2.50)	50.00 (3.50)	50.00 (3.17)	36.08 (3.09)	0.117
I prefer to use AR applications in my teaching	33.33 (3.33)	58.8 (3.53)	0.00 (2.70)	50.00 (3.50)	50.00 (3.50)	38.43 (3.31)	*0.044
I prefer textbooks to have more AR features for better pedagogy skill	66.67 (3.78)	82.35 (3.94)	70.00 (3.90)	100.00 (4.00)	66.67 (3.67)	77.14 (3.86)	0.748
I use AR applications to increase students' science learning performance	44.44 (3.22)	52.94 (3.41)	0.00 (2.70)	50.00 (3.50)	33.33 (3.33)	36.14 (3.23)	0.144
I use AR applications to increase inquiry based learning	40.74 (3.22)	58.82 (3.53)	0.00 (2.93)	58.33 (3.58)	47.22 (3.33)	32.74 (3.18)	0.113
Mean Average	42.22 (3.27)	60.78 (3.20)	0.00 (3.38)	59.72 (3.29)	49.54 (3.27)	43.36 (3.33)	

When comparing the responses of these 17 items, 2 significant difference items were found. A post hoc Dunn's multiple comparison test displayed adjusted value as shown in Table 4.

Table 4. Items with Significant Difference Results from Dunn's Multiple Comparison Test Results of Age Group Level of Agreement with Likert Statements

Age Group	Mean	Dunn's adjusted p value
I know how to use a tablet		
More than 50years	4.17	*0.004
36-40years	4.59	
I prefer to use AR applications in my teaching		
41-45years	2.70	0.066
36-40years	3.53	

The first item corresponding to using a tablet displayed that teachers of the age group of more than 50 years were less positive using tablet compared with their counterparts of 36-40 years of age. However, the second item, "I prefer to use AR applications in my teaching" displayed no significant difference of age group in teachers technological content knowledge based on adjusted Dunn's p-value.

Discussions

Teachers' Age Group towards Technological Knowledge in Augmented Reality

The teachers in this study were shown to be highly positive toward technological knowledge with the highest percentage and mean scores. The teachers in their late 30s seemed to be more technology-savvy in augmented reality compared to other age groups. These findings do not support the results by Alkhatabi [24]. He found that Saudi Arabian educators around the age of 25-35 displayed positive responses to the familiarity of AR applications while educators from the age group of 36-45 combined strongly agree and agree responses registered 58.62% against 72.93 % of the age 36-40, indicated in this study [24]. This group of teachers were also seen to be more positive on how to operate a smartphone, using a tablet, download, install but not into AR applications. Some researchers have tied the use of mobile phones to their experience operating computers suggesting more interaction using computers in terms of age may allow a better familiarity in operating a mobile phone. However, a study by Teo discovered that there is no significant relationship between age with computer attitudes [25].

Teachers' Age Group towards Technological Content Knowledge in Augmented Reality

Teachers in this study showed less positive towards teaching and learning science using AR. The lowest mean is for the item "I know about AR applications for doing science" registering only 46.81% indicating teachers may not be aware of AR applications found in Malaysian science textbooks. The data also suggested the same age group of 36-40 to have the highest mean compared to other groups. Thus, teachers in this survey need to at least consider the use of Augmented Reality in their teaching of science content in the classroom.

Teachers' Age Group towards Technological Pedagogical Knowledge in Augmented Reality

Results showed that teachers were not keen to use AR features in their pedagogy styles as well as inquiry-based science learning.

Teachers should transform themselves into constructivist teaching and inquiry-based science learning where students are given freedom and opportunity to construct their own understanding. A conducive environment for enhancing inquiry skills – scientific process skills, manipulative skills and thinking skills, and developing the 21st-century skills- C's creativity, critical thinking, communication, and collaboration can be presented to students using AR.

Based on the findings above it can be argued that the majority of the science teachers indicated in this study have sound technological knowledge but when focusing on technological content knowledge and technological pedagogy knowledge utilizing AR, the technology was not recognized as an important tool to incorporate into their teaching and learning. This argument is consistent with the findings by Omoniyi et al.[26]. The study conducted in 2019 surveyed 110 Nigerian teachers found that reluctant to change and reluctant attitude towards the use of AR accounted for fifty per cent of the participants. This lack of interest in using augmented reality may be caused by their insufficient knowledge on the benefits of using augmented reality in the classroom that facilitates learning and making an enjoyable lesson as supported by a study of Turkey pre-service teachers using AR in education [13]. The 2018 study found that only 21.8% of teachers aged 20-30 years knew about augmented reality suggesting not many young teachers are aware of using AR in a science classroom.

CONCLUSION

Summary and Implications

This research study has sought to provide information on teachers' age group on technological knowledge, technological content knowledge and technological pedagogical knowledge in augmented reality. Based on the findings of this study, the following conclusions were drawn:

- 1) There was no significant difference in teachers' age group in terms of using AR in the classroom.
- 2) Teachers of age group 36-40 were found to be more positive in using AR in science classrooms.
- 3) Teachers of age group 36-40 years old showed a significant difference than their counterpart of 50 years of age in using a tablet
- 4) No particular age group displayed a significant difference in technological pedagogical knowledge
- 5) No particular age group demonstrated a significant difference in technological content knowledge than other age groups.

Recommendations

Based on the summary of findings of the study, there is a need for attention and action by various stakeholders in science education, including school teachers, school principals, curriculum planners and developers, educational researchers and textbook writers. Hence, the following recommendations are advanced.

- 1) Science education should aim to develop teachers in promoting the use of technological knowledge, technological content and pedagogical knowledge in augmented reality in science classrooms. Students will benefit greatly from using augmented reality and may improve their understanding of science.
- 2) Curriculum decision-makers and textbook writers have paved the way forward by incorporating augmented reality in science textbooks but teachers in this study were found not to use those features. More exposure to the use of augmented reality in the form of professional development programmes is encouraged for teachers of all age groups.
- 3) Teachers of all ages are not only exposed to AR but be fortified to learn how to incorporate AR into their subject content knowledge and pedagogy knowledge for learning in the science classroom.

REFERENCES

- [1] Pierson, M. E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education*, 33(4), 413–430. <https://doi.org/10.1080/08886504.2001.10782325>
- [2] Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2011). Effects of Technology Immersion on Middle School Students' Learning Opportunities and Achievement. *The Journal of Educational Research*, 104(5), 299–315. <https://doi.org/10.1080/00220671003767615>
- [3] Yasak, Z., Yamhari, S., & Esa, A. (2010). Penggunaan teknologi dalam mengajar sains di sekolah rendah. *Seminar Majlis Dekan Pendidikan IPTA 2010*, 1–7. <http://eprints.uthm.edu.my/id/eprint/445/>
- [4] Neumann, D. L., Neumann, M. M., & Hood, M. (2011). Evaluating computer-based simulations, multimedia and animations that help integrate blended learning with lectures in first year statistics. *Australasian Journal of Educational Technology*, 27(2), Article 2. <https://doi.org/10.14742/ajet.970>
- [5] Agar, J. (2019). What is technology? *Annals of Science*, 0(0), 1–6. <https://doi.org/10.1080/00033790.2019.1672788>

- [6] Cetin-Dindar, A., Boz, Y., Sonmez, D. Y., & Celep, N. D. (2018). Development of pre-service chemistry teachers' technological pedagogical content knowledge. *Chemistry Education Research and Practice*, 19(1), 167–183. <https://doi.org/10.1039/C7RP00175D>
- [7] Koehler, M. J., & Mishra, P. (2009). What is Technological Pedagogical Content Knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70.
- [8] Hernes, F., Hestman, M., & Haaland, E. (2000). Knowledge and Competence in ICT among Teachers in Norway. Retrieved from <http://www.ifip.or.at/con2000/iceut2000/iceut09-04.pdf>
- [9] Zainal, A. Z., & Zainuddin, S. Z. (2020). Technology adoption in Malaysian schools: An analysis of national ICT in education policy initiatives. *Digital Education Review*, 0(37), 172–194. <https://doi.org/10.1344/der.2020.37.172-194>
- [10] Ebrahimi, S., & Jiar, Y. K. (2018). The use of technology at Malaysian public high schools. *Journal of Education and Review*, 6(3), 54–60.
- [11] Malik, S., Rohendi, D., & Widiaty, I. (2019). *Technological pedagogical content knowledge (TPACK) with information and communication technology (ICT) integration: A literature review*. 498–503.
- [12] Young, J. R., Young, J. L., & Shaker, Z. (2012). Technological Pedagogical Content Knowledge (TPACK) Literature Using Confidence Intervals. *TechTrends*, 56(5), 25–33. <https://doi.org/10.1007/s11528-012-0600-6>
- [13] Saidin, N. F., Dayana, N., Halim, A., & Yahaya, Y. (2015). *A review of research on augmented reality in education: Advantages and applications*.
- [14] Uygur, M., Yelken, T. Y., & Akay, C. (2018). Analyzing the views of pre-service teachers on the use of augmented reality applications in education. *European Journal of Educational Research*, 7(4), 849–860.
- [15] Nechypurenko, P. P., Starova, T. V., Selivanova, T. V., Tomilina, A. O., & Uchitel, A. D. (2018). Use of augmented reality in chemistry education. *Proceedings of the 1st International Workshop on Augmented Reality in Education Kryvyi Rih, Ukraine, October 2, 2018*, 2257, 15–23.
- [16] Yoon, S., Anderson, E., Lin, J., & Elinich, K. (2017). How augmented reality enables conceptual understanding of challenging science content. *Journal of Educational Technology & Society*, 20(1), 156–168. JSTOR.
- [17] Garzón, J., Pavón, J., & Baldiris, S. (2019). Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Reality*, 23(4), 447–459. <https://doi.org/10.1007/s10055-019-00379-9>
- [18] Ibáñez, M.-B., Di-Serio, Á., Villarán-Molina, D., & Delgado-Kloos, C. (2016). Support for augmented reality simulation systems: The effects of scaffolding on learning outcomes and behavior patterns. *IEEE Transactions on Learning Technologies*, 9(1), 46–56. <https://doi.org/10.1109/TLT.2015.2445761>
- [19] Rana, N. (2012). A study to assess teacher educators' attitudes towards technology integration in classrooms. *MIER Journal of Educational Studies Trends & Practices*, 190–205.
- [20] Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK) the development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, 42(2), 123–149.
- [21] Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2013). A review of technological pedagogical content knowledge. *Journal of Educational Technology & Society*, 16(2), 31–51.
- [22] Sural, I. (2018). Augmented reality experience: Initial perceptions of higher education students. *International Journal of Instruction*, 11(4), 565–576.
- [23] Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education 8th edition edited by Louis Cohen, Lawrence Manion and Keith Morrison (8th ed.)*. Routledge.
- [24] Alkhattabi, M. (2017). Augmented Reality as E-learning Tool in Primary Schools' Education: Barriers to Teachers' Adoption. *International Journal of Emerging Technologies in Learning*, 12(2).
- [25] Teo, T. (2008). Pre-service teachers' attitudes towards computer use: A Singapore survey. *Australasian Journal of Educational Technology*, 24(4).
- [26] Omoniyi, G. T., Nor, S. A., & Yusop, N. I. (2019). *The Journal of MacroTrends in Applied Science*. 7(1), 49–54.

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