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# Machine Learning Clustering Analysis Towards Educator's Readiness to Adopt Augmented Reality as a Teaching Tool

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**Abstract**

*The advanced digital revolution has shifted conventional teaching and learning into digital education. In consistency with digital education, Augmented Reality (AR) applications started to shine in the education industry for their ability to create conducive teaching and learning environments, especially in remote learning during the COVID-19 pandemic. Movement Control Order (MCO) implemented in the year 2020 has led to emergency remote teaching and learning without much preparation for all educators and learners. Throughout these few years, most educators got familiar with digital teaching tools and online teaching platforms. Hence, this study aims to explore educators' readiness to adopt AR as a teaching tool in their teaching during the endemic period. A quantitative approach via questionnaire has been distributed to the Private Higher Education Institutions (PHEIs) in the states of Selangor and Kuala Lumpur. Machine learning using a clustering technique was used to find patterns between the demographics of educators towards the AR perception of educators. The results revealed that educators' perceptions of AR technology are influenced by their familiarity with it, their personal beliefs, and their attitudes toward technology. This study provides an insightful overview of the benefits of AR applications in education and the implications of the adoption of AR in Malaysian schools and educational institutions. It also highlights the importance of motivating educators and students to embrace AR as an enhancement learning tool, providing a valuable discussion for the government, learning institutions, and educators on the implementation of AR in Malaysia.*

**Keywords:** *Augmented Reality, Clustering, K-modes, Perceived Usefulness, Perceived Ease of Use.*

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## 1 Introduction

In line with the advancement of the digital world, the significant progress of current technology has transformed conventional teaching and learning into digital education. When MCO was implemented by the Malaysian Government in March 2020 to control the COVID-19 spread, teaching and learning were conducted in digital teaching and learning mode without much preparation by the institutions, schools, educators, and learners. After more than 2 years of remote learning, teaching and learning mode has back to the new normal norm. During the disruptive period brought on by the COVID-19 outbreak, the education sector is heavily utilizing digital resources and e-learning systems.

When linked with sound pedagogical foundations, the use of technology in education has been demonstrated to have both positive and constructive effects. According to several researchers, technology-integrated instruction promotes more creative and engaging teaching and learning methods, which raises students' motivation [10, 15, 17, 28] while also improving the effectiveness of students' real-world learning experiences [56]. [61] suggest that three teaching elements of emphasis, augmentation, and integration are impossible to employ simultaneously when delivering a classroom lecture using a PowerPoint presentation hence virtual and physical integration functions of AR may be used to incorporate the elements and to assist the educators in delivering their lectures.

A more engaging, interactive, authentic, and pleasant learning environment has been created because of the incorporation of technology [12, 18]. The education system now incorporates a number of technologies, including multimedia, the internet, mobile devices, the Internet of Things (IoT), virtual reality, and augmented reality [33]. [48] invented the AR; he created and popularized the interface, which displayed 3D visuals on the head-mounted display. The characteristics of Augmented Reality technology and the trade-offs between video blending and the optical interventions that served as the foundation for AR research have been further examined by [9]. The International Symposium on Mixed Reality, the International Workshop and Symposium on Augmented Reality, and more conferences on AR were organized after that.

While real things are a crucial component of AR settings, some of these environments also require a virtual design in order to be developed. The technology allows users to interact immediately and spontaneously with virtual items through the manipulation of real objects without the need for expensive and complex hardware components because it has a significant representation of reality and does not require comprehensive 3D models [57]. With a well-designed approach and appropriate strategies, AR/VR technologies could offer higher benefits than the cost involved [47]. In contrast to virtual reality, augmented reality allows users to interact face-to-face. The potential of augmented reality as an improved teaching aid has not yet been considered because previous studies tend to concentrate on virtual reality.

Augmented Reality (AR) technology integrates virtual information into the physical world to enhance the user's perception and interaction with their environment [11], it can be utilized for a lesson like the three-dimensional anatomy of animals and humans [33], making it a good interactive tool to attract students' interest in their learning process [38, 55]. The AR-assisted teaching proposal [36], which indicates the viability of AR usage and is strongly encouraged to be included in teaching materials as it can boost students' learning autonomy, is highly recommended. Because users can also receive virtual audio-visual stimulation based on the real environment, AR technology is known to be sufficiently relevant to education [32]. In addition, the technology can include components like connectivity and activities that fit the demands of the learners [33], which boosts their motivation.

## 2 Literature Review

Existing literature reflects the benefits of AR applications especially in the education field. These studies have shown that AR applications for education are steadily increasing [20, 23, 39, 31, 33, 60]. It has also proven its worth in other industries, such as by bridging the knowledge gap regarding the actual world and enhancing productivity and efficiency in manufacturing, training, and product creation [44]. Many studies [20, 23, 39, 31, 33, 60] have been conducted to establish the tendencies, affordances, and challenges of this technology for education.

As augmented reality applications provide educational benefits, some Malaysian researchers have reported on them. A case study by [4] showed that the use of augmented reality (AR) significantly enhanced students' learning experiences in a programming course. The study found that the AR-enhanced programming course resulted in greater student engagement and motivation, as well as better performance on assessments when compared to the traditional course. Using the AR approach offers the benefit of providing learners with an up-to-date learning environment that can serve as a substitute for traditional learning methods [30]. The AR application with computational thinking is not only for teaching aid in the educational field yet it has proven that the approach can be integrated for problem-solving in learning [1]. The new role of the teacher has led to a novel way of interaction, increased learning motivation, and reduced mental pressure among students, resulting in more effective learning outcomes [52].

Additionally, previous studies conducted by [42], and [34] found that AR technology able to provide a better means of learners learning in an interactive environment. Thus, this interactive technology is able to enhance student-centered learning; learners able to interact with their peers and educators. Additionally, [29] noted that AR technology enables the learner to foster a sense of community among their peers while acquiring knowledge. Likewise, a study by [58] found that learners' prior experience with AR and 3D modelling, technical skills, and motivation were important factors that influenced their ability to use the technology effectively. It also identified that AR technology can enhance learning experiences, especially in complex subjects, and support collaborative learning, which shows the impact of AR on them.

Despite the aforementioned existing literature pointing out the benefits of AR applications for learners, assessing the readiness of the technology among learners and educators is equally important. Individuals differ in their attitudes toward adopting new technology; they may do so either through adaptation or rejection. Students who hold a more negative attitude towards AR and digital technologies, in general, tend to have lower levels of interest and motivation to engage with them. Additionally, they tend to be less confident in their ability to use the technology successfully. Moreover, female students are more likely to experience concerns about potential negative outcomes when using technology compared to male students [58]. The success of the product used in the teaching and learning processes is therefore thought to be influenced by educators' attitudes about new technologies. Not only is user acceptance a critical success factor, but its absence also presents a significant challenge that needs to be addressed [40]. Assessing the likelihood of a successful introduction of AR technology in the education sector requires highlighting educators' views about AR applications. It is important to note that there is little research on how instructors feel about augmented reality applications. However, a case study by [6] investigated teachers' perceptions and attitudes toward the use of augmented reality in a Jordanian primary school and found that they were positive, but the lack of training and technical support hindered their use of the technology.

In addition, [21] compares the usage of AR and other pedagogical tools and finds that when AR is embraced and used as the delivery method, learners are better at investigating and understanding the concepts. According to several studies [3, 20], AR enables teachers to present knowledge more effectively from the perspectives of the physical, cognitive, and contextual, which improves students' understanding of abstract concepts. In addition to the aforementioned point, [22] have demonstrated how mobile augmented reality may be used as an excellent teaching tool to show students at a Thai institution how 3D rendering works.

Additionally, [8] found that teachers had positive perceptions of using AR technology for language learning, with many believing that it could enhance student engagement, motivation, and learning outcomes. Teachers also believed that AR could provide opportunities for personalized and collaborative learning, improve visualization of abstract concepts, and offer immediate feedback to students. This is also supported by [27, 43] that teachers had positive attitudes towards the use of AR technology in education and recognized its potential to enhance student learning outcomes. However, it was also highlighted that future teachers lacked the necessary skills and knowledge to effectively integrate AR technology into their teaching practices.

According to [41], university teachers' perceptions of barriers to the use of digital technologies varied significantly depending on their academic discipline which include a lack of access to appropriate technology, insufficient training and support, and concerns about the impact of digital technologies on the quality of education.

### 2.1 Research Gap

Based on the review of past studies, there were no studies found on the perception among educators in Malaysia context using machine learning approach. [2] using statistical analysis found that providing teachers with training and support was crucial for the successful implementation of AR in the classroom. Another study using statistical analysis by [24] suggested that Malaysian secondary school teachers have a positive attitude towards using AR in teaching English reading. The study found that perceived usefulness, ease of use, attitude, and subjective norms were important factors that influence the acceptance and intention to use AR technology among the teachers. According to [37], researchers mainly applied the TAM model to explore teachers' acceptance of the application of evolving educational technology. The study also revealed that attitude significantly affected teachers' behavioral intention to use AR technology in the classroom. Teachers' technological proficiency, perceived usefulness and ease of use, and attitudes towards AR are critical determinants of their readiness to use AR in teaching as those who believe AR technology is useful together with a positive attitude towards the technology are more likely to be ready to use it in teaching [43].

A study done by [27] using statistical analysis focusing on in-service science teachers suggested that they have a positive attitude towards AR technology and are willing to integrate it into their teaching practices with adequate training, resources and support from school administrators. This is supported by a study using statistical analysis by [35, 51] which not only indicated that a positive attitude towards the use of AR technology is needed but also highlighted the importance of providing teachers with access to resources and support to effectively integrate AR technology into their teaching practices.

Additionally, the analysis on AR applications research using machine learning techniques is still yet to be explored. Machine learning techniques particularly clustering can be exceptionally valuable for research analysis, as they can help identify patterns and relationships in large datasets that may not be apparent to the human eye. According to [19], machine learning known as most powerful data-driven methods applied to materials discovery and tremendously predict the performances of the materials. Hence, it is being applied in the previous studies related to machine learning application in innovative materials science [19] and examine the best practices in machine learning for chemistry by [7]. Machine learning techniques can reveal new insights and relationships that researchers may not have considered before, allowing them to ask new questions and explore new avenues of research. According to [45], machine learning solutions offer a promising direction that can serve as a point of reference for potential research and applications, catering to the needs of both academic and industrial professionals, as well as decision-makers, from a technical perspective.

Thus, in this paper, machine learning clustering technique was employed to study the educator's readiness to adopt Augmented Reality (AR) as a teaching tool.

## 3 Methodology

### 3.1 Data Set

This quantitative study employed a questionnaire survey that was distributed to educators from five private universities in Malaysia upon approval from the universities. After filtering 350 questionnaires that were given to respondents, 261 valid questionnaires were computed into the Statistical Packages for Social Sciences (SPSS) software version 23.0 to generate a de-

Table 1: Measurement items.

| Constructs | Items | Descriptions |
|---|---|---|
| Awareness of AR | AW1 | I am aware that AR can be used as teaching aids. |
| | AW2 | I know that AR enables us to see the image using AR applications. |
| | AW3 | I know that AR can be applied in various fields. |
| Educator's innovative | EI1 | I enjoy teaching my students via the digital learning platform. (i.e: Kahoot, Blendspace). |
| | EI2 | I am up-to-date with the new digital technology in education. |
| | EI3 | I feel confident with digital technology in education. |
| | EI5 | I often search for better teaching aids. |
| Perceived usefulness | PU1 | I believe that AR will enhance my teaching preparation effectively. |
| | PU2 | Being able to use AR as my teaching aid will be useful. |
| | PU3 | Using AR in my teaching will reduce my time in repeating explanations to the students. |
| | PU4 | I can effectively manage my teaching with AR designing. |
| | PU5 | AR will help me explain difficult concepts. |
| Perceived ease of use | PEU1 | I feel comfortable to explore AR in my teaching as a teaching tool. |
| | PEU2 | I feel convenient in using AR as my teaching aid. |
| | PEU3 | I have fun using AR as my teaching aid. |
| | PEU4 | I feel that it is easy to use AR in my teaching. |
| | PEU5 | It will be easy for me to be skillful in IT when using AR. |
| | PEU6 | My interaction with AR will be clearer. |
| Attitude to adopt AR | AT1 | I like the idea of using AR as an enhancement for teaching aid. |
| | AT2 | I think using AR in my teaching plan is a good idea. |
| | AT3 | I think AR enables my students to enjoy the reality of the images. |
| | AT4 | I feel good with AR designing in my teaching plan. |
| | AT5 | I am able to accept AR as my teaching aid. |
| | AT6 | I feel good about adopting AR in my teaching. |
| Intention to adopt AR | IN1 | I intend to use AR as my teaching aid. |
| | IN2 | I would like to use AR in my daily teaching. |
| | IN3 | I am interested to include AR in my teaching plan. |
| | IN4 | I will apply AR in my teaching materials. |
| | IN5 | I will use AR soon. |
| | IN6 | I would recommend my colleague to use AR as their teaching aid. |

scriptive analysis of the respondents' profile. The data were also analyzed using the Python Scikit Learn with PyCharm IDE to generate the inferential analysis.

The questionnaire was comprised of two sections. Section A pertained to demographic questions such as gender, ethnicity, age, marital status, and highest educational level, while Section B was made of items to be scaled using the 3-points Likert scale ranging from 1 representing "low level", 2 representing "medium level" and 3 representing "high level". All measurement items are presented in Table 1.

Based on the past studies, several constructs related to Technology Acceptance Model (TAM) were used in this study which includes awareness of AR, educator's innovative, perceived usefulness, perceived ease of use, attitude to adopt AR, and intention to adopt AR to identify the factors that influence educators' and students' attitudes towards AR, which can inform the design of effective AR-based learning activities.

### 3.2 Descriptive Analysis

Based on Table 2, 66.37% of respondents were female and ranged in age from 31 to 35. 147 respondents (65.92%) were married, making up the majority of the sample. In addition, 16.59% of respondents were Indian, followed by 39.91% Malay and 39.91% Chinese respondents. The majority of participants (63.68%) held a Master's degree, and 22.87% held a doctoral degree. Prior to this investigation, more than 65% of the respondents were familiar with augmented reality.

### 3.3 Data Pre-processing for Clustering Analysis

The values of all the attributes used in this study were converted into categorical form so that an appropriate clustering algorithm that works best for categorical data can be applied. As the responses in Section A of the questionnaire were in categorical form, converting the responses from section B of the questionnaire which was in the form of numeric to categorical values having "low", "medium" and "high" would be more appropriate.

### 3.4 Clustering Analysis

The clustering technique has been known to be a popular unsupervised approach for analysing data in statistics, machine learning, pattern recognition, and data mining. It allows similar objects or items to be collected together to form a group or cluster [14]. Each cluster contains objects that are similar to each other but dissimilar to the objects of other groups. When a dataset is composed of a set of attributes $A = \{gender, age, e1, p2, ..., \}$, attribute or feature clustering consists on partitioning them into a set of K disjoint clusters $C = \{C_1, ..., C_K\}$ such that $\bigcup_{k=1}^{K} C_k = A$. The technique has been widely in various fields as reported by [5, 46].

Commonly clustering techniques can be divided into two types, hierarchical and partitional. In this study, partitional clustering was used. Common algorithms in use for partitional clustering are *K-means*, *K-medoids*, *K-prototype*, *K-modes* and others. Although *K-means* is widely used in applications [16] it works best for clustering on numerical data. Since this study deals with categorical data, *K-modes* was used instead. This algorithm is an extension of K-means algorithm [13] and is being widely used in applications. As for similarity measure to group or cluster attributes of non-numerical data, *simple matching coefficient (SMC)* was used [59]. Despite there have been many variants of *K-modes* in terms of clustering algorithms and dissimilarity measures, we only used the basic *K-modes* and *SMC*.

In this study, in order to determine the optimum number of k-clusters, we experimented with several k-values using index named *Davies–Bouldin (DBI)* [26], *Silhouette index (SI)* [53], and elbow method [50]. A low value of *DBI* signifies high intra-cluster similarity and low inter-cluster similarity while a higher silhouette coefficient refers to a model with more coherent clusters. PyCharm IDE tools with Python were used in this study as they are popular in academic research [48].

A total of 7 distinct clusters or groups were formed from the dataset used in this study. The selection of the appropriate number of clusters (k-value) was determined using the aforementioned methods. In the next section, tables depicting cluster size and a description of clusters will be presented.

Table 2: Cluster Size.

| Cluster No | Demographic description of clusters | Items |
|---|---|---|
| Cluster 1 (C1) | Female, Malay, 31-40, Married, Masters | 77 |
| Cluster 2 (C2) | Male, Chinese, 31-40, Married, Phd | 35 |
| Cluster 3 (C3) | Male, Chinese, 31-40, Single, Masters | 14 |
| Cluster 4 (C4) | Female, Chinese, 21-30, Single, Masters | 46 |
| Cluster 5 (C5) | Female, Chinese, 31-40, Married, Masters | 41 |
| Cluster 6 (C6) | Male, Chinese, $\geq$41, Married, Masters | 15 |
| Cluster 7 (C7) | Female, Chinese, 31-40, Married, Masters | 33 |

## 4 Results and Discussion

Table 2 shows that cluster 1 (C1) appears to be the largest cluster while C3 is the smallest. Generally, the proportion of male students is lower than the proportion of female students in the dataset. And this will be self-explanatory for cluster size C3 and C6. Clusters C2, C4, C5 and C7 are quite uniform in size. The total 7 clusters have good coverage of values for gender and age demographic attributes. This will facilitate comparing demographic category with awareness of augmented reality (AR), educators' innovation, perception of AR and adoption of AR categories between clusters which are presented in Table 3.

Table 3 shows that all the clusters except for C7 are highly aware on the existence of AR. Educators from all these groups of clusters have high level of educators' innovation towards AR technology in education regardless of gender, race, age, marital status and education level. These clusters however have different level of perceptions of AR where some clusters (C1, C2, C4) have high perceptions of AR in terms of both its usefulness and ease of use. This could be due to having access and exposure to the necessary technology and resources. Whereas other clusters (C3, C6, C7) have high perceptions of AR usefulness, yet moderate perceptions on its ease of use. However, cluster C5 has moderate perceptions for both aspects. Most of the clusters have high tendency and intention to adopt AR technology as part of their teaching tools, except for C5 and C6.

Educators' prior experiences with AR technology, either positive or negative, can also influence their perceptions of its usefulness and effectiveness. Some educators may have grown up with technology and may be more comfortable and familiar with using AR technology compared to others. Furthermore, some educators may already be aware on the effectiveness of using AR which can enhance student engagement and motivation by providing interactive and immersive learning experiences. Even though some educators may have lack of awareness on AR, yet more access to training and professional development opportunities focused on AR and other emerging technologies could give them more exposure on the use of AR as part of the teaching tools as they showed high interest in adapting AR. Some demographic factors such as age and gender can shape educators' perceptions of AR technology, but it is important to note that these factors are not determinative, and that individual experiences and attitudes also play a significant role.

The findings are consistent with [54] who used statistical analysis on his study among educators from private universities in Malaysia and [25] his study found that users' attitudes and intentions toward using AR and VR for learning are influenced by their perceptions of the usefulness and ease of use of these technologies, as well as their experiences with them and social influence. Educators who are more familiar with AR technology may have a more positive perception of its use in teaching compared to those who are less familiar with it. Educators' personal beliefs and attitudes towards technology can also play a role. Those who are more open to incorporating technology in their teaching may have a more positive perception of AR, while those who are more traditional in their approach to teaching may be skeptical of it.

## 5 Conclusion

Over the past few years, there has been a rapid increase in the popularity of virtual and augmented reality. The perceptions of educators regarding the usefulness and effectiveness of AR technology can be influenced by their previous encounters with it, whether those experiences were positive or negative. Educators who are more familiar with AR technology tend to have

Table 3: Description of Clusters.

| Cluster label | Demographics | Awareness of AR | Educators' Innovation | Perception of AR | Adoption of AR |
|---|---|---|---|---|---|
| C1 | Female, Malay, 31-40, Married, Masters | Aware of AR and high level of awareness of AR | A high level of educators' innovation is evident | Perception of AR in terms of usefulness and ease of use are both high | Adoption of AR in terms of attitude and intention are both high |
| C2 | Male, Chinese, 31-40, Married, Phd | Aware of AR and high level of awareness of AR | A high level of educators' innovation is evident | Perception of AR in terms of usefulness and ease of use are both high | Adoption of AR in terms of attitude and intention are both high |
| C3 | Male, Chinese, 31-40, Single, Masters | Aware of AR and high level of awareness of AR | A moderate level of educators' innovation is evident | Perception of AR in terms of usefulness and ease of use are high and moderate respectively | Adoption of AR in terms of attitude and intention are both high |
| C4 | Female, Chinese, 21-30, Single, Masters | Aware of AR and high level of awareness of AR | A high level of educators' innovation is evident | Perception of AR in terms of usefulness and ease of use are both high | Adoption of AR in terms of attitude and intention are both high |
| C5 | Female, Chinese, 31-40, Married, Masters | Aware of AR and moderate level of awareness of AR | A moderate level of educators' innovation is evident | Perception of AR in terms of usefulness and ease of use are both moderate | Adoption of AR in terms of attitude and intention are both moderate |
| C6 | Male, Chinese, 41 above, Married, Masters | Aware of AR and high level of awareness of AR | A high level of educators' innovation is evident | Perception of AR in terms of usefulness and ease of use are high and moderate respectively | Adoption of AR in terms of attitude and intention are high and moderate respectively |
| C7 | Female, Chinese, 31-40, Married, Masters | Not aware of AR and moderate level of awareness of AR | A high level of educators' innovation is evident | Perception of AR in terms of usefulness and ease of use are high and moderate respectively | Adoption of AR in terms of attitude and intention are both high |

a higher level of comfort and confidence in using it. Some educators may already recognize the effectiveness of incorporating AR into teaching practices, as it can heighten student engagement and motivation by offering interactive and immersive learning opportunities. Overall, it is important for schools and educational institutions to assess the readiness of their teachers to use AR as a teaching tool and provide appropriate support and training to facilitate its effective integration into teaching practices. Nonetheless, the results are based on limited data sets covering private universities in Peninsular Malaysia. The next direction of the study could be focusing on other clustering algorithms, bigger data sets focusing on a wider scale of both private and public universities in Malaysia, and the use of other AI techniques for the non-statistical analysis.

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