The impact of individual, scientific and organizational factors on the adoption of AR in university education

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Abstract

Purpose – Augmented reality (AR) is an advanced version of the dynamic physical space that is perceived and received via visual, audio, digital and other sensory stimuli. The capabilities of virtual technologies change the field of university and education considerably. The necessity of using virtual technologies in the education field was revealed more in unforeseen disasters such as the COVID-19 pandemic. The adoption of a technology by its users is an important factor in the successful implementation of the technology. The present study evaluates several factors affecting the adoption of AR technology in the realm of tertiary education.

Design/methodology/approach – This study is applied in nature, and the necessary data were gathered through a survey questionnaire. The opinions of 621 students were investigated using a simple random sampling method. The multinomial logit test was used in this research.

Findings – It was found that individual and social factors such as age, education level, major and economic characteristics such as one's income in a month, expenses of a person in a month, the level of access to high-speed internet and access to a laptop or smartphone are effective in AR technology adoption in the field of academic education.

Originality/value – The theoretical contribution of this study is to identify the key factors that influence the adoption of AR technology and develop a model specifically applicable to the educational field. The results of this research can be used by university managers and educational policymakers for the efficient and effective use of this technology.

Keywords Augmented reality, University, Technology adoption, Disruptive technologies

Paper type Research paper

Introduction

Augmented reality (AR) turns the surrounding environment of the user into a dynamic and interactive space. At the beginning of the advent of this technology, even the possibility of using AR in different sectors of industries was like a dream (Ronaghi, 2024). But now, AR has swiftly risen to the forefront of industry trends. Today, AR is making massive changes in various fields (Ronaghi and Ronaghi, 2022). The initial idea of AR was designed to be used to inform people under certain situations. With the increasing progress of technology, many

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applications have been proposed for this idea, one of the most important of which is education.

With the emergence of this technology, marketers and technological companies have been obliged to cope with the notion that AR is nothing more than a marketing tool. In order to increase public understanding of AR, some of the early adopters of this technology have developed technologies that have provided the possibility of consumer shopping experience (Chen and Lin, 2022). Indeed, by considering AR as an option in the catalog, stores allow consumers to imagine how the products will look in different environments (Oyman *et al.*, 2022).

Almost every industry and organization has found methods to use AR technology to improve their processes and results (Ronaghi and Ronaghi, 2021). Various organizations have used this technology, the most common of which are educational institutions and the applications of AR across diverse academic disciplines. The effect of AR in education has made dynamic, AR-based instructions enable people to do new tasks more easily and quickly compared to traditional educational methods. As AR-based wearables, like smart glasses and headsets, become more widely available, there is a high potential to use AR in academic settings (Liu *et al.*, 2022). Various studies have referred to the capabilities of AR in different academic fields.

In the field of tourism, Shen *et al.* (2022) examined the determinants of adopting AR applications in tourism higher education amidst the COVID-19 pandemic. To achieve this goal, their research was grounded in the theoretical framework of the technology acceptance model. Their research model has been investigated in tourism departments at Chinese universities, and it was based on students' perspectives. A total of 604 Chinese students made up the sample population for this study. The data were analyzed using partial least squares structural equation modeling. The results revealed that perceived usefulness, hedonic motivation and price value are significant factors influencing Chinese students' adoption and usage of AR applications.

In the field of engineering, Arulananda *et al.* (2020) employed a framework for integrating AR into mobile phones for engineering education. They introduced a novel educational approach, termed M-Learning, which leverages mobile devices for teaching.

In the field of agriculture, Huuskonen and Oksanen (2019) examined AR for supervising multi-robot systems in agricultural field operations. They revealed that AR is a powerful tool for real-time information visualization. In agricultural fleet management, they presented a new AR system to assist the farmer to supervise the performance of two agricultural machines.

In the field of education, Koutromanos's study (2023) examined the factors that influence pre-service and in-service teachers' intention to use mobile augmented reality in their teaching through the proposed mobile augmented reality acceptance model. A multi-group analysis of pre-service and in-service teachers revealed similar outcomes, with only slight variations between the two groups.

Similarly, by performing a quasi-experimental study, Ronaghi (2023) showed that virtual reality (VR) technology is also effective in teaching sustainable behavior among students. He divided 105 students into three groups, and after conducting eight training sessions, it was found that the training of VR-based technology showed better results than the traditional training.

As mentioned, many studies have focused on the AR technology implementation and the capabilities of this technology in the academic field. Accordingly, one can find the advantages of using AR technology compared to traditional methods in the academic field. According to previous studies, the research gap is the investigation of the successful implementation of AR technology in academic settings. Indeed, the success of deploying a technology is related to its adoption by users. Thus, the main problem of this research was to examine the critical factors in the adoption and implementation of AR technology among students in the field of education. The question of this research is:

> What are the critical factors that shape students' attitudes toward AR technology adoption?

AR in education provides a variety of advantages that foster critical skills development like problem-solving, collaboration and creativity, preparing students for future success. Additionally, AR supports traditional pedagogy by effectively imparting technical knowledge and proficiency.

The importance of utilizing virtual technologies in education was highlighted even more during critical situations such as the COVID-19 pandemic (Ronaghi, 2022). A crucial factor in the successful implementation of a technology is its adoption by users. The theoretical contribution of this study is to understand the influences on the decision to adopt and utilize AR technology and provide a model related to the field of education. This research provides an overview of important individual, economic and social factors in the adoption of AR at different educational levels and can help provide a more suitable ground for more practical application of this technology. The results of this research can be used by university managers and educational policymakers for the successful deployment of this technology.

AR in education

Along with various applications of AR, this technology has influenced the traditional education process. AR has the potential to revolutionize the when and where of learning, offering innovative and supplementary methods. AR technology can make classes more attractive and information more understandable as well as increase communication interaction and provide a safe environment for learning. The learning process should be accompanied by creativity and interaction, in which AR can be helpful (Nelson *et al.*, 2022).

AR technology can convert complex and abstract concepts into interactive 3D models, creating a more supportive and inclusive learning environment for students to visualize and comprehend difficult subjects. For instance, the Polytechnic Institute of Leiria, Portugal, has successfully incorporated AR into its mathematics programs. In online class discussions, AR can act as a surrogate teacher, providing guidance and instruction when human teachers are not available.

AR can be applied in many academic fields. For example, AR applications for medical students can be one of the methods of deep learning (Menon *et al.*, 2022). In the same area, Urlings *et al.* (2022) investigated the potential and performance of AR in educating patients. This study's population comprised patients with various chronic conditions, including prostate cancer, diabetes and epilepsy. The quantitative results revealed that utilizing AR significantly enhances patient knowledge and satisfaction. Additionally, the qualitative findings indicated that patients were enthusiastic about this technology and felt at ease using it for educational purposes. However, the quality of the evidence was moderate to low, and the existing research suggests that AR's potential in patient education is promising but requires further investigation. In addition, Suneesh *et al.* (2022) examined the impact of AR in nursing education. They examined student experience in performing lung and heart assessment with AR and compared the learning outcomes of students participating in traditional training of heart and lung assessment with those participating in the AR-enhanced training. In their study, they demonstrated that developing training and self-confidence in heart and lung learning assessment skills using AR was done on students.

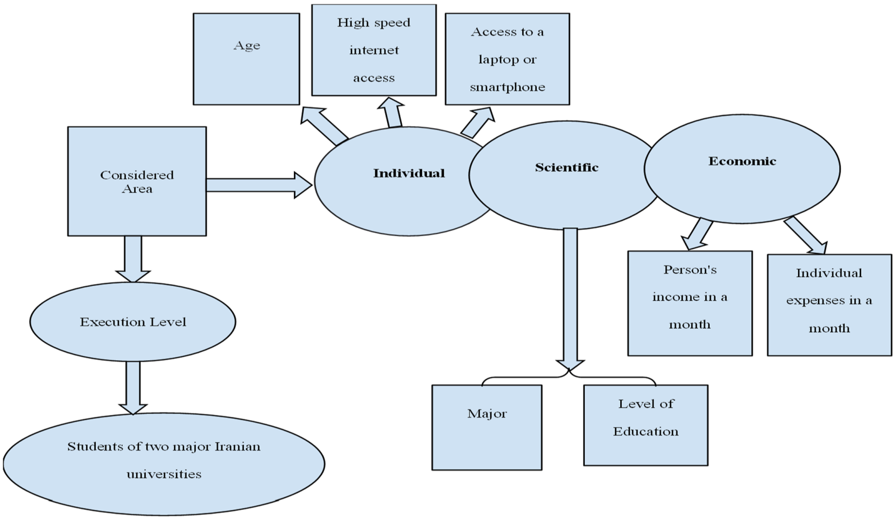
In the field of engineering, Kaur *et al.* (2020) investigated the effectiveness of AR in promoting student motivation and interactive learning in engineering programs. They showed that in engineering education, hands-on learning is crucial to complement theoretical concepts with practical experience, thereby maximizing learning outcomes. However, many students struggle to apply their knowledge in practical ways, despite having a theoretical understanding of fundamental concepts. This is often due to a lack of motivation stemming from non-interactive course content, which hinders effective concept visualization and student engagement in the classroom. As a result, students who struggle to understand traditional teaching methods may find it challenging to develop a deep understanding of concepts. By leveraging tools like AR, students can visualize and interact with classroom materials, boosting their motivation to learn and enhancing their overall learning experience.

In the field of agriculture, Oksanen (2018) also investigated the role of drones and AR in optimizing soil sampling procedures for precision agriculture. This article introduces a novel approach that leverages drone imaging and wearable AR technology to streamline soil sampling. By generating a soil map after plowing, the method automatically identifies optimal sampling locations and guides users to these points using AR guidance. These are the results of work done in southern Finland. They concluded that the AR application was intuitive and effectively guided users to all sampling locations, allowing for efficient collection of sample points with minimal user input required.

In the field of management, Alirezaei *et al.* (2022) pointed out that while technologies like Building Information Modeling (BIM) and AR have shown great promise, research exploring the challenges and opportunities of combining these technologies for cost and schedule risk management is scarce. To address this gap, the authors presented a comprehensive and proactive BIM-AR risk management system that enables real-time monitoring of project cost and schedule risks. Their innovative system utilizes AR on commercial smartphones to collect real-world risk data (such as risk type and likelihood), performs an online Reverse Failure Mode and Effect Analysis and updates a BIM model of the project to provide risk-mitigation solutions. This research significantly contributes to the existing literature by offering a cutting-edge approach to risk management in construction projects.

AR applications in education can be divided into three categories: special applications for students, children and applications for self-learning (Roopa *et al.*, 2021). Although AR is being embraced across various industries, its impact on education and universities is particularly significant. AR features can provide students with new tools to visualize complex topics and concepts as well as gain practical skills (Shen *et al.*, 2022).

As discussed, numerous studies have explored the application of AR technology, highlighting its benefits over traditional methods. However, a research gap remains in investigating the successful implementation of AR technology in educational institutions and universities. Specifically, the key challenge is to identify the factors influencing the integration of AR technology in educational settings among student populations, as the success of technology deployment is deeply tied to user adoption. This research endeavor seeks to understand the factors that influence the acceptance and utilization of AR technology in educational contexts among students in different study fields. This research provides an overview of important individual, economic and social factors in the adoption of AR at different educational levels and can help provide a more suitable ground for more practical application of this technology. This brief analysis presents a foundation for further investigation and innovation in education and information sharing. Given the importance of AR in the education field, in order to use this technology, there is a need to examine the factors that facilitate or hinder students' adoption of this technology. In this research, the individual, scientific and economic issues of a person accepting technology in two important universities in Iran have been investigated. By considering the above factors and the UTAUT model, the research conceptual model was presented in Figure 1.



Source(s): Figure by authors

Figure 1. Research conceptual model

Methods

A survey design was used in this study, which was conducted during the spring and summer of 2022. A questionnaire, developed in collaboration with seven information technology experts, was employed as the data collection method, so its face validity was verified. The studied population consisted of students from two major Iranian universities, including Shiraz University and the University of Medical Sciences. An electronic questionnaire was sent to 850 students and 621 questionnaires were received using the random sampling method. After collecting the data via questionnaire, the parameters of the model were estimated using the STATA software and a regression model. In the regression model, the explanatory variables can be either quantitative, qualitative or a combination of both. Similarly, the dependent variable can be either quantitative or qualitative in nature. As illustrated in Table 1, the dependent variable in this study is a qualitative variable that has been categorized into five distinct levels based on expert opinions and classifications. If the dependent variable is $y = 1$, it indicates the person's complete awareness of AR and his access to technology. If the dependent variable is $y = 2$, the person is fully aware of AR and has no access to technology. In the dependent variable $y = 3$, one is unaware of AR and does not have access to technology. $y = 4$, a person is unaware of AR and has access to technology. $y = 5$, he has incomplete information about AR and does not have access to technology.

Level	Characteristics
y = 1	The person is fully aware of AR, and has access to technology
y = 2	The person is fully aware of AR, and he has no access to technology
y = 3	The person is unaware of AR and does not have access to technology
y = 4	The person is unaware of AR, and has access to technology
y = 5	The person has incomplete information about AR, and does not have access to technology

Source(s): Table by authors

Table 1. Description of the dependent variable

This study employs the multinomial logit model, which is suitable for analyzing a nominal dependent variable with more than two categories. Given that the dependent variable in this research has five distinct modes and the order of the options is not significant, we opted for multinomial logit regression instead of order logit. This approach enables us to model the relationships between the independent variables and each of the five categories of the dependent variable. To validate the use of the multinomial logit model, a parallel regression test was conducted. This test assesses the validity of the hypothesis that parameters are equal across all groups. The results of this test, presented in Table 2, reveal that the assumption of parameter equality across groups is not supported, indicating significant differences between groups. Given the significance of the X2 statistic in the parallel regression test, it can be inferred that the parameter values vary across groups, supporting the acceptance of the general pattern. Therefore, the multinomial logit model has a solid foundation.

The following equation represents the structure of the multinomial logit model:

$$\begin{aligned} Pr &= (y = mIx) = X'\beta_m \\ \beta_m &= (\beta_{0m}, \beta_{1m}, \ldots, \beta_{km}) \end{aligned} \tag{1}$$

The effect of m on the result is shown in Equation (2), which is utilized to construct a probability model for multinomial logit, predicting the probability of each potential outcome.

$$pr(Y_i = mI\,x) = \frac{exp(x_i\beta_m)}{\sum_{j=1}^{j} exp(x_j\beta_i)} \tag{2}$$

Equation (2) expresses the probability of the dependent variable y taking on a value m, given the independent variables x, as the product of the likelihood function of the independent variables, the parameters and the normalization constant. Since logit models are discrete, the logarithm of the likelihood function is utilized in the estimation process, as shown in Equation (3), to facilitate calculation and ensure numerical stability.

$$\mathrm{lnL}\big((\beta_2, \ldots, \beta_j)y, x\big) = \sum_{m=1}\sum_{y=m} \frac{exp(x_i\beta_m)}{\sum_{j=1}^{j} exp(x_j\beta_m)} \tag{3}$$

To assess the impact of changes in each independent variable on the probability of people's knowledge and use of technology, we calculate the partial derivative of Equation (4) with respect to the variable of interest. This derivative reveals the marginal effect of each independent variable on the probability, allowing us to examine the relationships between the variables and the outcome.

Table 2. Parallel regression test results

Model	-2log likelihood	Chi-square	Sig.
Null hypothesis	1244.829		
General	1106.452	69.326	0.000

Source(s): Table by authors

$$\frac{\partial pr(y = mI\, x_i)}{\partial x_k} = pr(y = mI\, x)\left[\beta_{km} - \sum_{j=1}^{j} \beta_{kj} pr(y = jIx)\right] \quad (4)$$

By doing so, we can calculate the partial derivatives that quantify the influence of each variable on the probability, providing insights into the marginal effects of each independent variable on the outcome.

Results

The studied sample was characterized by individual, social and economic factors. Given the crucial role of individual, social and economic factors in shaping the characteristics of the study sample population (Moghaddam and Rezaei-Moghaddam, 2017), in this section, the personal and sociodemographic attributes of the sample population, such as age, education level and major and economic characteristics such as one's income in a month, the expenses of a person in a month and the amount of high-speed internet access, laptop or smartphone access, are considered. The methodology in this research is descriptive-analytical. Field studies (questionnaires by students) were used to collect the required data, and STATA software was employed to estimate and analyze the econometric model, providing insights into the relationships between the variables. To obtain the students' tendency to adopt AR, the data used in Table 3 was obtained via questionnaires and interviews.

As shown in Table 3, the average age of students is 27.5 years, indicating a relatively young student population with a range of 19–36 years. The variable of education level was considered as B.A. (1), M.A. (2) and Ph.D. (3). Regarding the literacy level of the students, most of the students had a B.A. According to the interviews conducted with students, a few had a Ph.D. We also divided students' majors into four general categories, which include engineering, humanities, medical and agricultural fields.

One's expenses within a month are at least 400 thousand tomans if a single person lives with a family and a maximum of eight million tomans for students living in a city outside their hometown or married people. The reason why some expenses are high is due to the payment of house rent and the obligation to pay family expenses. As shown in Table 3, a few students are employed outside the university in the questionnaires. According to Table 3, the studied students have a monthly income of up to ten million tomans. Internet access variables and laptop or smartphone access variables were divided into three groups: no access, limited access and full access.

Multinomial Logit model

After describing the mentioned variables and estimating the multinomial logistic regression model, the model's estimation results are presented in Table 4. It should be mentioned that in

Variables	Unit	Standard deviation	Min	Max
Age	Year	9.08	19	36
Level of education	Grade	1.01	0	3
Major	–	0.5	0	4
Individual expenses in a month	million tomans	4.2	400,000	8,000,000
A person's income in a month	million tomans	3.2	0	10,000,000
High-speed internet access	–	1.01	0	4
Access to a laptop or smartphone	–	1.01	0	4

Source(s): Table by authors

Table 3. Characteristics of students in the study sample individual, social and economic characteristics

the multinomial logistic regression model in software estimation, one class is considered as the base class. In this study, the third class, comprising individuals who are unaware of AR and lack access to technology, serves the base or reference category (Ronaghi, 2021).

Discussions

In the logit model, the likelihood ratio test is employed to assess the overall significance of the model and its goodness of fit, determining whether the model is a significant improvement over a null model. The likelihood function compares the coefficients of the explanatory variables in the constrained state, the state in which all the coefficients are zero, with the unconstrained state. In this model, a log-likelihood value of 634 (with a p-value of 0.04) indicates a well-fitting model, suggesting that the explanatory variables effectively capture the variation in the dependent variable. However, due to the non-linear nature of the multinomial logit model, the coefficient values cannot be directly interpreted as the final effects of the explanatory variables on the dependent variable. Thus, the final effects that were explained above have been calculated for the explanatory variables in Table 5.

As presented in Table 5, if y = 1, it indicates one's full awareness of AR technology and access to technology, the final impact related to income variables, education at the master's

Significant dependent variables	O	C	I	E	F	IN	L
Y = 1	S	-S	S	S	NS	S	S
Y = 2	S	-S	S	S	NS	S	S
Y = 4	NS	-NS	S	-S	S	S	NS
Y = 5	NS	-S	S	S	S	S	S

Note(s): IN = internet access, C = individual expenses in a month, F = field of study, O = age, E = education, I = individual income in a month, L = access to a laptop, S = significant at the 90% confidence interval and NS = not significant

Source(s): Table by authors

Table 4. The estimated results of the multinomial logit model

Level	Dependent variables	Prob	Level	Dependent variables	Prob	Level	Dependent variables	Prob	Level	Dependent variables	Prob
Y = 1	O	0.16	Y = 2	O	0.65	Y = 4	O	0.32	Y = 5	O	0.33
	C	0.32		C	0.02		C	0.18		C	0.05
	I	0.04		I	0.01		I	0.04		I	0.04
	E = 1	0.64		E = 1	0.03		E = 1	0.61		E = 1	0.09
	E = 2	0.001		E = 2	0.04		E = 2	0.01		E = 2	0.02
	E = 3	0.015		E = 3	0.03		E = 3	0.02		E = 3	0.001
	L = 1	0.22		L = 1	0.04		L = 1	0.11		L = 1	0.85
	L = 2	0.18		L = 2	0.02		L = 2	0.13		L = 2	0.04
	L = 3	0.002		L = 3	0.13		L = 3	0.08		L = 3	0.02
	IN = 1	0.62		IN = 1	0.001		IN = 1	0.08		IN = 1	0.13
	IN = 2	0.14		IN = 2	0.02		IN = 2	0.14		IN = 2	0.02
	IN = 3	0.001		IN = 3	0.24		IN = 3	0.9		IN = 3	0.03
	F = 1	0.01		F = 1	0.01		F = 1	0.56		F = 1	0.01
	F = 2	0.30		F = 2	0.21		F = 2	0.99		F = 2	0.44
	F = 3	0.04		F = 3	0.02		F = 3	0.07		F = 3	0.01
	F = 4	0.07		F = 4	0.15		F = 4	0.16		F = 4	0.09

Source(s): Table by authors

Table 5. Results of marginal effects

and Ph.D. level and the third level of full access to the Internet and laptop in the fields of engineering and medicine are significant (Wake *et al.*, 2020). As shown in level 1, being fully aware of AR, an individual's likelihood of adopting AR technology increases by 4% for every increment in income as their financial capacity grows. That is, the increase in income increases the buying power of necessary equipment and increases the tendency to AR adoption. This issue can also refer to affordability and disposable income. AR technology can be expensive, making it more accessible to individuals with higher financial capabilities. Also, with more financial resources available, individuals may be more likely to invest in AR technology for personal use, such as studying. The obtained results are also similar to the study of Faqih and Jaradat (2021).

In addition, with the increase of one's education, the person's awareness of AR increases, and the likelihood of accepting AR technology is increased by 1.5 and 0.01% points, respectively (Scaravetti and Doroszewski, 2019). Besides, full access to laptops and the internet is significant in the third level with the values 0.2 and 0.1%, which have a positive impact on one's technology acceptance. Among the four academic majors, engineering and medical fields with coefficients of 1 and 4% have the highest effect on AR adoption, which indicates the necessity of using this technology to better perceive the concepts in this major (Brunetti *et al.*, 2015).

If $y = 2$, one is fully aware of AR and does not have access to the technology. The final effect related to the variables of income and cost has a significant impact on the acceptance of technology, meaning that with an increase in income and a decline in costs, the probability of AR adoption is increased by 1 and 2%, respectively. This result diverges from findings in developed countries, where studies like Wong *et al.* (2020) have shown that AR technology adoption is not significantly impacted by income and cost factors. This divergence may be due to various factors, including:

(1) Affordability: Over the last few years, AR technology has become increasingly accessible and affordable in developed countries, democratizing access and making it easier for people to adopt, regardless of their income level. This increased affordability has bridged the gap, enabling a wider range of individuals to harness the power of AR, regardless of their financial means.

(2) Perceived value: Users may perceive AR technology as valuable and worthwhile, regardless of the cost, due to its unique features and benefits.

(3) Subsidization: Some AR technologies may be subsidized by governments, organizations or companies in developed countries, opening them up to a wider range of users.

(4) Democratization: AR technology has become more democratized, with many free or low-cost options available, reducing the impact of income and cost on adoption.

(5) Early adopters: The study might have focused on early adopters of AR technology, who are often more enthusiastic and less price-sensitive.

With the increase in the individual's education level in all three levels of bachelor, master and doctorate, the probability of adopting AR technology is increased (Gandedkar *et al.*, 2021). Since $Y = 2$ is the level of one's lack of access to technology, no access and low access to a laptop and the Internet have a noticeable impact on a person's propensity to accept AR, because in the absence of a laptop and the Internet, it is impossible to use this technology, and the person is less inclined to accept this technology. At this level, the willingness to accept technology has increased for individuals in engineering and medicine fields by 1 and 2%, respectively (Anderson *et al.*, 2021).

If y = 4, the person is unaware of AR and has access to technology. The final effect related to the variables of income and education level is meaningful, which shows that when someone is utterly unaware of technical knowledge, other items such as the field of study and access to a laptop and the Internet do not influence one's acceptance of technology. As a result, raising a person's level of awareness about AR has a significant effect on technology acceptance (Chang *et al.*, 2022). This finding that raising awareness of AR does not significantly impact technology acceptance may be specific to the Iranian context. In other societies, the relationship between awareness and acceptance may differ due to various factors. As Brown *et al.* (2017) noted, if people fail to see the relevance of AR to their lives or work, increased awareness may not lead to adoption. Moreover, past experiences and biases can shape individuals' attitudes toward new technologies, reducing the impact of awareness. The perceived complexity of AR may also lead to decreased adoption, even with increased awareness. Additionally, mere awareness without hands-on experience may not convince individuals to adopt AR. Furthermore, constant exposure to new technologies can lead to desensitization, making awareness less effective in driving acceptance. According to Statista Market Insights, the adoption of AR and VR devices remains limited, with growth projections until 2027 falling short of the scale needed to make mixed reality "the next computing platform" in the near future. This year, an estimated 98 m people will use VR hardware, while 23 m will experiment with more advanced AR technology. By 2027, both AR and VR are expected to surpass 100 m users worldwide, but this still lags far behind the billions of smartphone users globally.

If y = 5, the person has incomplete information about AR and does not have access to technology. The final effect related to income and cost variables has a significant impact on AR adoption with 4 and 5%, respectively, in order to increase one's financial ability to provide the necessary equipment to access AR technology. Also, due to the incomplete information of the individual at this level, the increase in the education level in the master's and Ph.D. levels also has a substantial influence on the growth of an individual's motivation to accept technology at 2 and 0.01% because it raises the awareness of the individual. The obtained result can be due to the following reasons:

(1) Exposure to innovative technologies: Higher education institutions often provide students with hands-on experience with cutting-edge technologies, including AR. (2) Development of critical thinking and problem-solving skills: Master's and Ph.D. programs foster logical reasoning, analysis and strategic thinking, enabling individuals to better understand and appreciate the potential of AR. Faqih and Jaradat (2021). (3) Increased familiarity with digital tools: Advanced education often involves extensive use of digital tools, making individuals more comfortable with technology and more receptive to adopting new innovations like AR. (4) Enhanced understanding of AR applications: Higher education provides a deeper understanding of AR's practical applications, making individuals more likely to recognize its value and potential impact. (5) Greater openness to new ideas: Individuals with advanced degrees tend to be more open-minded and receptive to novel concepts and technologies, including AR. (6) Improved digital literacy: Master's and Ph.D. programs often include courses on digital literacy, further enhancing individuals' ability to effectively utilize and adapt to new technologies like AR. (7) Networking opportunities: Higher education provides opportunities to connect with professionals and researchers in various fields, potentially exposing individuals to AR experts and enthusiasts. (8) Increased confidence in technology adoption: Advanced education can boost individuals' faith in their capacity to acquire new technological skills, making them more willing to accept AR (Theodoropoulos and Lepouras, 2021).

By possessing these skills, knowledge and attitudes, individuals with master's and Ph.D. degrees are more empowered to understand and appreciate the potential of AR, leading to a greater willingness to accept and adopt this technology. Access to a laptop and the Internet at the second and third levels has a significant effect on the adoption of individual technology. At this level, engineering and medical students were more willing to adopt AR (Menon *et al.*, 2022).

Recommendations

The current findings align with previous research, such as the study done by Menon *et al.* (2022) and Shen *et al.* (2022). As stated earlier, AR can be used in many academic fields, among which the most important fields are medicine and engineering. AR applications for medical students can be one of the methods of deep learning. This underscores the need for AR technology adoption in higher education. The present study attempts to provide an effective step to provide a suitable ground for all students to adopt this technology by examining the determinants of students' acceptance of AR technology. This study has several limitations. First, the Multinomial Logit model relies on questionnaire data from a small sample of students, which may not be representative of the larger population. Additionally, the study is constrained by the limitations of software production in Iran and the impact of sanctions (Ronaghi, 2021). Furthermore, the qualitative nature of the research variable presents challenges in terms of generalizability. Future studies can address these limitations by employing time series models or panel data to capture a broader range of data. Alternatively, structural equation modeling can be used to develop a more comprehensive methodology. A promising area for future research is a comparative analysis of new technology adoption between developed and developing countries, which can inform solutions for improving access to and utilization of modern technologies, particularly in education. Moreover, extending this study to investigate educators' perceptions of emerging technologies like AR in developing countries would provide valuable insights into the challenges and opportunities in this context.

Our concluding recommendation is regarding the modality choice in AR solution deployment plans. Most analyzed papers failed to justify their AR modality choice, raising questions about understanding the impact of modality on learning efficacy, teaching quality and technological diffusion. Currently, no research compares different AR modalities in education, highlighting the need for investigation. Different interaction methods can lead to issues affecting adoption, as seen in other fields (Zhou *et al.*, 2016). In the context of AR education, Ibáñez *et al.* (2020) identified significant modality effects that varied depending on the societal background. Building on this finding, we recommend that the AR research community further investigate the impact of modality on teaching and learning outcomes. A deeper understanding of these effects could inform the development of more effective AR-based educational interventions, particularly in diverse learning contexts.

Conclusion

A key advantage of AR is that it is an excellent educational tool that can provide rich content and context. AR has the potential to enhance users' knowledge and awareness by providing an enhanced experience. This technology provides personalized training and promotes the learning process. Based on AR technology, real-time sharing of experiences is possible among users across long durations. Given the importance of AR in education, this research investigated the key factors that influence the adoption and use of AR technologies in Iranian universities by implementing a developed Multinomial logit model as a theoretical foundation.

The results in this research showed that if a person is fully aware of AR, with the increase in income, the person's financial capability increases and the probability of adopting AR increases. That is, the increase in income increases the buying power of necessary equipment and increases the tendency to AR adoption. Besides, full access to laptops and the internet is significant in the third level and has a positive impact on one's technology acceptance. Among the four academic majors, engineering and medical fields have the highest effect on AR adoption, which indicates the necessity of using this technology to better perceive the concepts in this major.

The COVID-19 pandemic has precipitated a global crisis in higher education, necessitating a rapid shift to e-learning and exacerbating existing challenges in designing and delivering effective student experiences. In this context, innovation and adaptability have become essential for universities to thrive. AR offers a promising solution, enabling the creation of engaging, interactive and immersive learning experiences that can enhance the efficacy of remote education. While AR applications are not a panacea for university education and present their own set of challenges, they have the potential to revolutionize the learning and teaching experience. However, their successful implementation hinges on a thoughtful and well-managed approach, taking into account the needs and capabilities of both students and educators. This paper argues that a considered and strategic method is crucial for harnessing the potential of AR in university education and mitigating its challenges. To achieve this strategic goal, access to the internet and laptops as important elements that the university is required to prepare suitable conditions for better access to them as well as the level of awareness of professors and students in some fields such as engineering and medicine, emphasizes the need to adopt this technology in education. In Iran, education policymakers should focus on the human and economic factors of students in addition to the technological infrastructure for the successful establishment of AR.

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