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The Current State of Virtual Reality and Augmented Reality Adoption in Vietnamese Education: A Teacher's Perspective on Teaching Natural Sciences

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***Abstract*—Virtual Reality (VR) and Augmented Reality (AR) technologies are increasingly applied across various fields, including education. However, in the Vietnamese education system, their use is still in its nascent stages. This article aims to analyze the current state of VR and AR adoption in the Vietnamese education system by evaluating two key aspects: the factors influencing the integration of VR and AR in teaching, and their roles in the Vietnamese educational context. The analysis is based on a survey conducted among 427 natural science teachers to assess the extent of technology adoption for instructional support, focusing on five factors: job positions, work locations, expertise levels, internet infrastructure, and English language proficiency. The research results reveal that, although VR and AR technologies have made their way into education, their adoption in Vietnam remains somewhat limited. The surveyed teachers indicate that the use of VR and AR enhances students' learning experiences, making them more immersive and engaging when compared to traditional teaching methods. However, they do not have a comprehensive understanding of the full potential and roles of VR and AR in education. The findings obtained from this study serve as a foundational insight for future research, aimed at proposing solutions to leverage VR and AR technologies to improve student learning outcomes in a developing country like Vietnam.**

***Keywords*—augmented reality, current state analysis, natural science education, Vietnamese education, virtual reality**

I. Introduction

Augmented Reality (AR) technology has garnered significant attention in the field of science education due to its potential to elevate learning experiences. AR involves overlaying digital information onto real-world objects or locations, to enrich the user's experience. Notably, AR distinguishes itself from virtual reality by allowing users to maintain a strong connection with their physical surroundings. This technology holds a multitude of positive applications, ranging from training the future workforce to empowering individuals with disabilities. Its exploration extends across domains such as medicine, marketing, museums, fashion, and other sectors [1]. Its presence is increasingly visible within audio-visual media, gradually permeating other facets of our lives in concrete and exciting ways. Moreover, AR is poised to provide learners with instant access to location-specific information aggregated from numerous sources [2].

Augmented Reality stands out as a technology that seamlessly combines virtual elements with the real world in real time [3]. AR is acknowledged as one of the foremost technologies of the 21st century and is recognized as a cornerstone of the Industry 4.0 program [4]. The process of AR involves superimposing virtual entities onto real-world images captured by cameras, thus engendering a distinct sense of reality when compared to Virtual Reality (VR) [5]. Its applications are widespread, encompassing domains like industry, education, healthcare, and language acquisition [6–8]. AR applications create a three-dimensional reality that presents the digital world as a tangible phenomenon, thereby offering solutions to the challenges encountered by students [6]. By simplifying complex subjects and bolstering student interest and attitudes toward courses, AR has the potential to enhance learning outcomes [9, 10]. AR technology can address the limitations of traditional computer-assisted teaching by providing a contagious and immersive virtual learning environment [11].

The research has unequivocally demonstrated that immersion in a digital environment can revolutionize education across multiple dimensions. To begin, both VR and AR facilitate the exploration of various perspectives, empowering students to grasp the intricacies of complex concepts [12]. By immersing students in realistic and comprehensive experiences, these technologies effectively foster a sense of presence and heightened engagement. Furthermore, the use of VR and AR enhances situated learning, enabling students to apply their knowledge within real-world contexts, which in turn promotes improved retention and transfer of learning. These technologies further hold promise for delivering personalized and adaptive learning experiences tailored to individual student preferences and needs [13]. Within the field of language education, the integration of AR and VR technologies has shown remarkable potential for enhancing the learning environment, boosting student motivation, and promoting interactive learning. By providing a rich multimedia experience, VR and AR facilitate improved visualization and comprehension of language concepts [14]. Additionally, these technologies can be harnessed to create immersive language learning scenarios, enabling students to practice

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language skills within realistic and interactive virtual environments. Furthermore, AR and VR can offer advantages for students with special learning needs, furnishing alternative modes of engagement and support. Approaches based on VR and AR, such as simulation and virtual worlds, have been demonstrated to be equally effective in terms of learning satisfaction and academic performance [15]. These technologies afford students realistic and interactive experiences, allowing them to refine and develop their skills within a controlled and secure environment. The COVID-19 pandemic has further illuminated the potential of VR and AR in education. As schools closed and remote learning became necessary, VR and AR technology were deployed to facilitate virtual classrooms and interactive learning experiences [16]. These technologies have enabled students to continue their education remotely, while also offering collaborative and immersive learning opportunities.

In Vietnam, VR and AR technology are making their presence felt in education. In the realm of chemistry education, virtual experiments can simulate complex phenomena that are challenging to replicate, thereby enabling learners to comprehend the essence of substances and their behaviors. These virtual chemistry experiments spark curiosity, passion for scientific exploration, creativity, and a thirst for uncovering new knowledge among students [17]. Utilizing software to construct 3D simulations in organic chemistry education helps students cultivate their chemistry competencies [18]. An initiative involving the integration of a heritage information data model with VR and AR seeks to digitally preserve cultural heritage in Ho Chi Minh City, Vietnam. The endeavor's goal is to fashion a virtual tour and bolster historical preservation efforts, thereby elevating the significance of both tangible and intangible cultural heritage within the city [19, 20]. While the studies offer valuable insights into the potential incorporation of VR and AR technology across diverse educational contexts, limited research has scrutinized the factors shaping teachers' utilization of these technologies to enhance student competency. This study aims to:

1) Examine the factors influencing the ability of teachers to apply VR and AR technology in teaching;
2) Analyze the roles of implementing VR and AR in enhancing student competencies in the field of natural science education in Vietnam.

In the context of the Fourth Industrial Revolution, Vietnam is striving to modernize education programs to gain advanced educational systems. The issue of technology integration in teaching has become an effective tool to achieve this goal. In this study, through teacher surveys and statistical analysis, the results aim to address the following questions:

1) Which factors influence the adoption of VR and AR technology in teaching?
2) How do the recognized factors impact the utilization of VR and AR technology in teaching?
3) How do Vietnamese teachers evaluate the roles of VR and AR in enhancing students' learning effectiveness?

The results of this study will provide educators and teachers with a fundamental basis for developing effective strategies to integrate VR and AR technology, thereby contributing to improving student learning outcomes.

II. Literature Review

Augmented Reality has gained significant attention in the realm of science education due to its potential to enhance learning experiences. AR offers unique advantages by providing visual and interactive representations of abstract scientific concepts, facilitating better comprehension of complex phenomena [21]. In science education, AR has been employed to create three-dimensional representations of challenging concepts, contributing to improved understanding and retention of scientific knowledge [22]. AR also offers the advantage of providing visual and interactive representations of abstract scientific concepts. This can help students better understand and visualize complex scientific phenomena. AR can be used to create three-dimensional representations of images and events that are difficult to visualize in traditional learning settings [23]. AR technology enhances learning motivation through its interactive and immersive nature, captivating students' attention and fostering intrinsic motivation [24, 25]. It also facilitates deeper understanding and retention of scientific information by allowing students to manipulate virtual objects and observe dynamic processes [26]. AR promotes the development of higher-order thinking skills such as critical thinking, problem-solving, and decision-making, as it engages students in hands-on and interactive experiences [27]. It encourages the analysis and application of scientific knowledge in authentic contexts and supports the development of spatial skills, which are crucial in various scientific disciplines.

AR has been applied across various scientific disciplines to simplify abstract concepts, making them more accessible to students [24]. For instance, it has been employed to enhance spatial skills in STEM education, promoting spatial skill development [28]. The influence of VR and AR on learning outcomes and knowledge retention has been a focal point. Huang *et al.* [21] performed a study evaluating the educational impact of AR and VR mobile applications on science knowledge retention. A systematic review and meta-analysis conducted by Mokmin and Rassy [29] homed in on AR technology's role in education, spanning science education as well. Their analysis indicated that AR's predominant use was in the natural sciences, mathematics, and statistics. Findings illustrated a positive effect of AR on students' academic achievements in these subjects. The literature also delves into the perceptions of both teachers and students regarding the use of AR in science education. AR's application in chemistry education has shown promise in visualizing intricate chemical structures. Traditional two-dimensional visualizations are still prevalent in this field, but AR's ability to present 3D molecular models offers students a more comprehensive perspective, aiding comprehension and memory retention [30]. Physics educators have utilized AR to simulate experiments, providing students with hands-on experiences in a controlled environment. This not only enhances their grasp of fundamental principles but also cultivates problem-solving skills and motivation [31]. AR technology both improved the students' laboratory skills and helped them to build positive attitudes towards physics laboratories. The statements of the students and the instructor regarding other effects of AR technology on science laboratories, both negative and positive, are also discussed [32].

Many teachers displayed positive attitudes toward AR's potential in science education [33]. A scoping review conducted by Jdaitawi *et al.* [34] further explored the significance of AR technology in science education. The review encompassed 26 studies published from 2015 to 2020, collectively demonstrating a favorable impact of AR on science education [34]. Notably, the review emphasized AR's potential to amplify learning outcomes and engage students within the realm of science education. The integration of VR and AR technology into teacher professional development has also been explored. Hatzilygeroudis *et al.* [35] outlined the pedagogical advantages of AR and VR in teacher training and offered insights into designing and developing online professional development programs for K-12 educators. Their work underscored the potential of AR and VR to enhance learning quality and stimulate episodic student memory. In a meta-analysis undertaken by Yilmaz and Batdi [36], the effects of AR applications in science education were scrutinized. The study employed a meta-analysis grounded in document analysis to assess the outcomes of various studies on AR applications in science education. Their findings illuminated a dearth of comprehensive studies in the realm of AR's impact on science education, with most existing studies leaning toward qualitative analysis. Nielsen et al. engaged expert science teachers, ICT designers, and science education researchers in a survey to explore AR's potential for student learning. The study underscored the significance of prioritizing "learning before technology" and identified affordances linked to interactivity, a creator's perspective, and inquiry-based science [37].

While AR offers numerous advantages, its adoption in education comes with challenges and limitations. These include equipment and software costs, technical constraints, the need for specialized teacher training, and potential health issues associated with extended AR device usage [38, 39]. Resistance or discomfort among some students and teachers when using new technologies like AR can also be a barrier [24]. Additionally, the efficacy of VR and AR may vary depending on the educational context and specific objectives, emphasizing the need for further research to maximize their potential for immersive learning [40].

AR technology presents a promising avenue for enhancing science education by improving motivation, comprehension, retention, and higher-order thinking skills. However, its implementation requires addressing technical, training, and contextual challenges to fully harness its benefits in education. Extensive research and development efforts are essential to unlock the full potential of immersive technologies like AR in the learning environment.

III. Methodology

The natural sciences subjects (including Physics, Chemistry, and Biology) in Vietnam are introduced to students starting from secondary school. To objectively assess the influence of factors on the utilization of VR and AR technology in teaching these subjects, three groups of teachers as participants were chosen in our survey. These teachers participate in teaching at three educational levels: universities, high schools, and secondary schools. All survey participants possess a fundamental knowledge of technology (computers, smartphones). They all have expertise and teaching experience related to the field of teaching natural sciences subjects. Therefore, receiving contributions from these three groups of teachers at different educational levels in our survey is appropriate to achieve the research objectives. The reason survey questionnaires were predominantly sent to secondary school teachers is our desire to conduct further research on applying VR and AR technology in teaching natural sciences to secondary school students in Vietnam.

The survey was developed by the authors, basing on the theoretical background of the research. It includes two contents to find factors influencing the ability of teachers to apply VR and AR technology in teaching and nine questions to have *t*eachers' evaluations of the role of VR and AR in Vietnamese education. The instruments were used to assess the current state of Virtual Reality and Augmented Reality adoption in Vietnamese education.

Hereafter, the participants in the survey are collectively referred to as natural sciences teachers. All of them voluntarily filled out the questionnaire we provided and no paid for this work and no costs were borne by the participants. We have recorded five general pieces of information related to teachers and identified them as factors that might influence the ability to apply VR and AR technology in teaching. These five factors are: 1. Education-related job titles; 2. Teachers' working locations; 3. Teachers' highest educational qualifications; 4. Internet infrastructure at teachers' workplaces; 5. Teachers' English language proficiency.

We incorporated five factors into various types of questions and an online survey with teachers. Participants were asked about their experiential information, that related to the use of VR and AR applications in teaching. This was done to evaluate the influence of the five mentioned factors on the ability to implement VR and AR in education. Subsequently, we obtained responses from 437 teachers regarding the factors relevant to the issue: The number of years teachers have been using technology for teaching, such as computers and smartphones, which serve teaching activities involving VR and AR. After filtering the data and removing inappropriate responses (e.g., answers to questions with four options reduced to only 1 or 2 options, or incomplete responses from teachers), we obtained responses from 427 teachers that aligned with the research purpose. Among the 427 collected responses, about the five identified factors for gathering influencing information, the obtained data is as follows:

- Job titles of teachers: University Lecturers (78 people); High school Teacher (192 people); Secondary school Teachers (157 people).
- Working location of teachers: Urban areas (250 people); Rural areas (136 people); High mountain areas (41 people).
- Highest educational qualification of teachers: PhD (28 people); Master's degree (157 people); Bachelor's degree (242).
- Internet infrastructure for educational purposes.
- English language proficiency of teachers: Divided into five levels: Very good, good, average, limited and very limited.

The survey was conducted within the period from the 1st to 25th December 2022 using the "Google Forms" application and was distributed to participants through links on various internet forums. Participants volunteered to complete the questionnaire, and the questionnaire was designed to ensure anonymity. At the beginning of the questionnaire, the context and purpose of the study were briefly described. In the longer section of the questionnaire, participants were asked personal information questions. Most of the questionnaire was structured using the Likert scale. The average time required to complete the questionnaire was around fifteen minutes.

The results of teachers' responses are utilized for analysis and evaluation of the influence of the five identified factors on the ability to apply VR and AR in education. According to the research team's perspective, computers, smartphones, internet infrastructure, and English language proficiency are the primary tools teachers can use to explore the roles of VR and AR and apply these technologies in teaching. The questions asked to teachers about the five factors to assess their impact on the use of VR and AR technology in education are constructed as questions numbered 1–4 in the questionnaire.

To analyze teachers' evaluations of the roles of VR and AR in Vietnamese education, the constructed questions were assessed as the following issues: the extent to which teachers are aware of and have experienced VR and AR technology in real-life situations and education; teachers' assessments of how VR and AR impact the field of education; and what users expect from AR/VR in education in the future. To answer for these questions, the following process was followed:

Step one: Construct a questionnaire for teachers regarding three issues (Questions 5–8):

- The awareness of VR and AR technology in teachers' real-life situations.
- Level of experience with VR and AR technology in teachers' real-life situations.
- Level of usage of VR and AR technology in teaching by teachers.

To enable teachers to comprehend and thereby recognize the roles of VR and AR in education, educators were provided the opportunity to preview and engage with the following content before participating in discussions regarding the roles of VR and AR in teaching.

- Participating in a 1-hour online course on the principles of VR and AR to know how VR is applied in education.
- Watching a video on operating a VR-based analytical instrument to understand the instrument's components.
- Attending a short training course to learn how to utilize AR technology in education.

Step two: Create a questionnaire for teachers regarding the role of VR and AR technology in education (9 issues).

Step three: Collect and analyze teachers' evaluations of the roles of VR and AR in Vietnamese education.

Step four: Propose effective solutions for teachers to apply VR and AR technology in education (four solutions). The responses collected from the questionnaire were analyzed, and subsequently, they were summarized meaningfully to derive results. The content of these subsection questions focused on issues including the features and benefits of VR and AR in teaching. These evaluations are presented in the results section of this article. The entire research methodology of this article is summarized in Fig. 1.

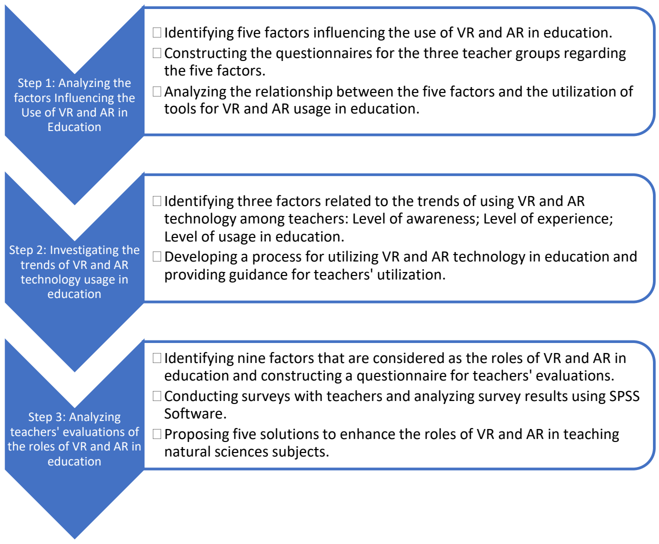

Fig. 1. Research flow of VR and AR survey and research purposes.

IV. Results and Discussion

A. Results

1) Factors influencing the ability of teachers to apply VR and AR technology in teaching

a) Career and academic qualifications of respondents

The survey results illustrated in Table 1 show that out of 157 secondary school teachers participating in the survey, there are 8 teachers, accounting for 5.09%, who reported using computers and smartphones for less than 5 years. None of the surveyed teachers have MS. and PhD. degree indicated using computers or smartphones for less than 5 years. Most of the secondary school, high school teachers, and university lecturers affirmed using computers and smartphones for over 10 years, constituting a range from 82.80% (Secondary school teacher) to 87.18% (University lecturers). Additionally, 41 out of 242 high school teachers, representing 16.94%, claimed to have used computers and smartphones for a duration between 5 to 10 years. This affirms that Vietnam is a developing country where information technology or infrastructure has developed to meet.

Table 1. Distribution of the respondents according to years of computer and smartphone usage

Years of computer and smartphone usage	Career			Academic qualifications		
	University lecturers	High school teachers	Secondary school teacher	BSc.	MS.	PhD.
Above 10 years	68	160	130	170	124	24
Five to ten years	7	30	19	69	33	4
Below 5 years	3	2	8	3	0	0
Total	78	192	157	242	157	28

It is also clear that there is a relatively consistent relationship between teachers' educational background at all three levels—Philosophy Doctor (PhD.), Master's (MS.), and Bachelor's (BSc.) and their years of computer and smartphone usage. Teachers at all three educational levels affirm a relatively long usage period of computers and smartphones, exceeding ten years. However, as the educational background level increases, the proportion of those using these tools for more than ten years also increases, with the highest being 85.71% (PhD.). Among these, Bachelor's degree holders have a higher percentage of users with less than ten years of usage, 69 out of 242 respondents, or 28.51%. Based on these results, the research team affirms that educational background is indeed a necessary condition for effectively integrating VR and AR into education.

b) Working locations of teachers

One factor influencing the number of years of computer and smartphone usage is the working location of teachers. The investigation results are depicted in Fig. 2. Among the three working locations: highlands, rural areas, and urban areas/towns, the highest proportion of computer and smartphone users with over ten years of usage is observed in urban areas/towns, accounting for 61.32%. Conversely, the lowest proportion is found in the highlands, with only 9.75% having over ten years of usage. These results align well with the reality of differing infrastructures across various regions in Vietnam. Mountainous regions possess weaker infrastructures compared to urban areas, even though teachers' working locations have sufficient internet infrastructure. Many teachers have reported issues with internet access, including situations where the internet is available but often unreliable or requires significant waiting time for access. Hence, the working location significantly influences both the number of years and the quality of computer and smartphone usage among teachers. Detailed survey data is aggregated and analyzed in Fig. 2.

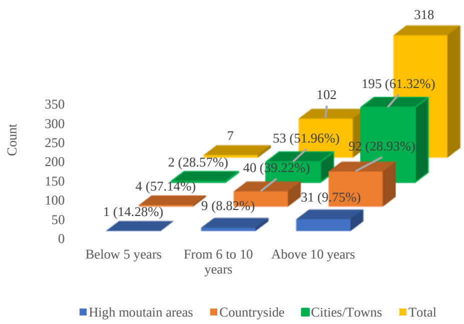

Fig. 2. The distribution of respondents according to the working locations of teachers and years of computer and smartphone usage.

c) Internet infrastructure

According to the evaluation results from teachers regarding the internet infrastructure for teaching purposes (Fig. 3), most teachers affirm having internet infrastructure and good usage quality. Out of 250 teachers in urban areas/towns, 155 teachers (62%) assert having good-quality internet. However, this sentiment is not shared by teachers working in highland regions, where only 36.5% confirm this, and a significant portion of teachers (43.8%) in highland areas claim to have internet, but with limited quality such as slow network speed or connectivity issues. Additionally, a noteworthy number of teachers in different regions assert not having internet for usage: 13 teachers in urban areas/towns (5.2%), 16 out of 136 teachers in rural areas (11.76%), and in highland areas, 19.51% of teachers affirm the absence of internet for teaching. The survey results about internet infrastructure align well with the survey findings about teachers' working locations and their years of computer and smartphone usage (Fig. 3).

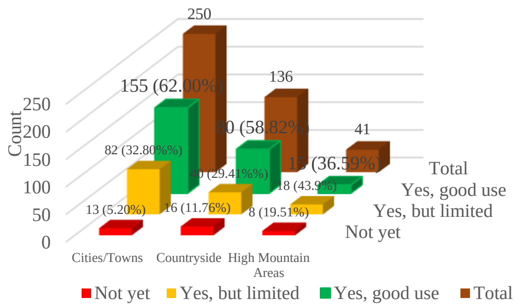

Fig. 3. Teachers' evaluation of internet infrastructure.

d) English proficiency of teachers

The results presented in Fig. 4 depict surveyed data concerning the current state of English proficiency and years of computer and smartphone usage among teachers. The findings reveal that even though the usage of these tools exceeds 10 years, 76.79% of teachers assert that their English proficiency is limited, with 85.11% rating their proficiency as very limited. Only 70.18% of teachers confirm having a good level of English. Additionally, as shown in Fig. 4, among the 260 respondents, 190 individuals (73.08%) evaluate their English proficiency as average. Therefore, it can be deduced that despite having moderate to limited English language skills, teachers can still meet educational needs using new technologies, with minimal impact on the application of VR and AR in education.

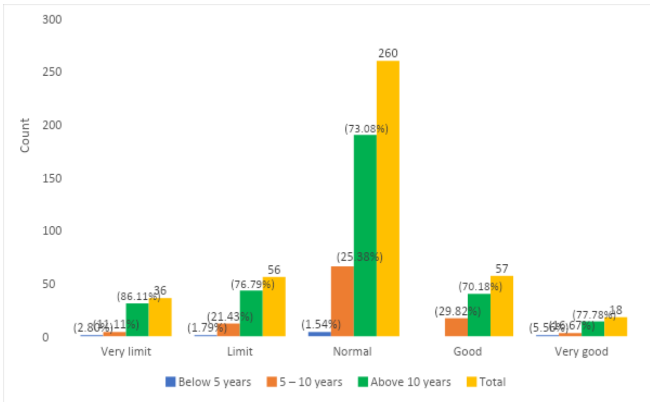

Fig. 4. The distribution of respondents reflecting years of computer and smartphone usage and English proficiency of teachers.

2) Surveying teachers' trends in using VR and AR technology

a) Survey results of information sources knowing about VR and AR in practice

It is practically evident that a substantial 81.73% of the surveyed teachers (349 out of 427) affirm that they only know about VR and AR technology through mass media (Fig. 5). This outcome is related to the findings from Fig. 6, where 66.04% of teachers assert that they have never experienced these technologies in their daily lives.

In addition, a modest number of teachers, 26.23%, report regular exposure to these technologies, while a mere 0.94% state they use them very frequently in their daily lives (Fig. 6). The results also make it clear that none of them claim to have received training or education in the use of VR and AR for teaching. This finding is related to the evaluation of teachers' level of experience with these technologies in the context of teaching (Fig. 5).

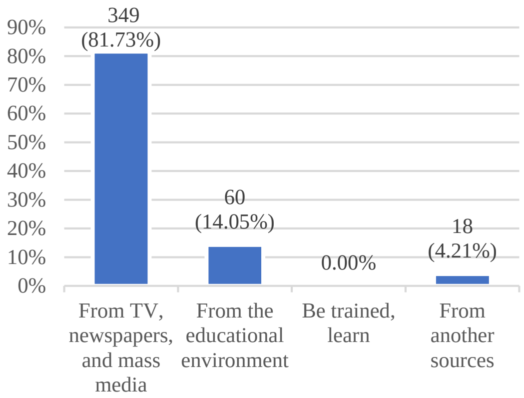

Fig. 5. Percentage of teachers having experiences of VR and AR technology.

b) Survey results of teachers' experience with VR and AR technology

Fig. 6 indicates that a small proportion, accounting for 26.23% of teachers, confirm their regular use of VR and AR technology in real-life situations. On the other hand, Fig. 7 reveals that 19.12% of teachers are sure of their utilization of these technologies in teaching and have plans to continue doing so. The intriguing aspect of Fig. 7 is that, although 310 out of 427 individuals (72.6%) assert not having used them yet, they express intentions to incorporate these technologies in their teaching soon. This demonstrates the readiness of teachers to embrace VR and AR technology in education.

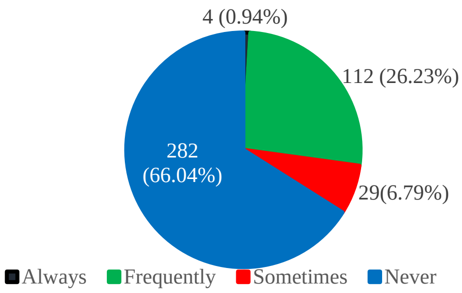

Fig. 6. The level of respondent's experience of VR and AR technology in practice.

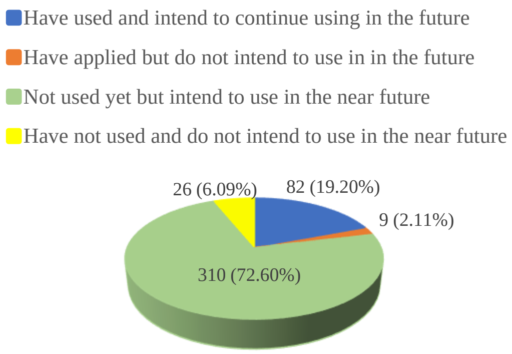

Fig. 7. The level of teacher's use of VR and AR technology in teaching.

c) Survey results on the teacher's use of VR and AR in teaching

Only a very few (6.09%) teachers admit to not having used these technologies and have no intentions of doing VR and AR soon. This suggests that teachers hold a favorable qualitative evaluation of the role of VR and AR in education. To provide more quantitative and accurate assessments of the benefits of VR and AR in education, we employed these technologies to create virtual experiments, molecular structure models, instrumental analysis, and instructional procedures for teachers. Subsequently, a survey was conducted to solicit more authentic evaluations from teachers about the role of VR and AR after they had experienced these technologies in an educational context.

3) Teachers' evaluations of the role of VR and AR in Vietnamese education

The teacher survey was conducted to gather their evaluations of the role of VR and AR in education. The questionnaire consisted of 9 questions, labeled from Q1 to Q9, using a 5-level Likert scale including Strongly Disagree = 1; Disagree = 2; Neutral = 3; Agree = 4; and Strongly Agree = 5. Data was collected from 427 teachers and processed using SPSS 22.0 software.

The measurement of reliability was performed using Cronbach's Alpha coefficient. Internal consistency implies that the observed variables within a scale must have strong positive correlations, contributing to a common concept. Cronbach's Alpha is an indicator of this internal consistency. Therefore, if the observed variables within a scale are tightly interrelated, the scale demonstrates high internal consistency, leading to a higher Cronbach's Alpha coefficient. The statistical results reveal that the Cronbach's Alpha coefficient for the 9-question questionnaire is 0.988, which exceeds the threshold of 0.6 (Table 2), and the observed variables all exhibit inter-correlations greater than 0.3 (Table 2). Thus, the scale demonstrates reliability, and the observed variables provide meaningful and well-explained insights.

Table 2. Item-total statistics

No.	**Statements regarding VR and AR**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
Q1	An enriched and captivating learning experience compared to studying through books, websites, or videos.	0.963	0.985
Q2	Knowledge will be presented in a visual and easily accessible manner	0.947	0.986
Q3	Save time in studying and researching.	0.949	0.986
Q4	Cost-effective compared to other learning tools	0.950	0.986
Q5	Meet individual learning needs and preferences	0.948	0.986
Q6	Stimulate multiple senses to facilitate a deeper understanding of abstract educational content."	0.939	0.986
Q7	Social interaction and collaboration.	0.922	0.987
Q8	Diverse and curiosity-driven education	0.971	0.985
Q9	Safer than using real experiments.	0.910	0.988

The mean represents an intrinsic value within a variable, posing a question. It indicates whether respondents agree or disagree with the viewpoint of that question. A high Mean implies agreement with the presented viewpoint, while a low Mean implies disagreement. Statistics from Table 3 show:

1) Question Q6 has the highest Mean value of 3.96. This reflects the reality of teaching natural sciences where

many phenomena occur that are not observable with the naked eye, such as models of chemical reactions, reaction mechanisms, molecular structures, or the internal components of physical devices. In such cases, using VR and AR devices helps students easily observe these phenomena, leading to a better understanding of their essence.

2) Question Q9 receives high agreement from teachers (Mean = 3.94, it has the second highest value), which aligns with the educational reality in Vietnam. Teachers in secondary schools not only teach in classrooms but also directly guide students in experiments and practical activities. The practical hands-on experience often involves hazardous chemicals, flammable substances, and potential dangers for both teachers and students. Moreover, the psychology of secondary school students is marked by curiosity and restlessness. They sometimes overlook safety rules and experiment precautions, including fire and explosion prevention. Hence, using VR and AR technology helps mitigate accidents that can occur in the laboratory.

3) Question Q1 has the third highest value, with a Mean of 3.81, indicating that using VR and AR enhances students' learning experiences, making them much richer and more engaging compared to traditional methods of learning.

Furthermore, the statement Q2, Mean = 3.79, also asserts the agreement of teachers on the role of VR and AR in enhancing visual and easily accessible aspects of using these tools in education.

Table 3. Descriptive statistics of teacher assessments

No	Statements regarding VR and AR	N	Mean	Std. Deviation
Q1	An education experience that is more diverse and engaging than studying through books, websites, or videos.	427	3.81	1.27
Q2	The knowledge will be presented in a visual and easily accessible manner.	427	3.79	1.18
Q3	Save time in studying and researching.	427	3.00	1.29
Q4	Cost-effective compared to other learning tools.	427	3.22	1.19
Q5	Meet individual learning needs and preferences.	427	3.15	1.36
Q6	Stimulate multiple senses to facilitate a deeper understanding of abstract educational content.	427	3.96	1.16
Q7	Social interaction and collaboration.	427	2.88	1.32
Q8	Diverse and curiosity-driven education.	427	3.64	1.35
Q9	Safer than using real experiments.	427	3.94	1.06

Notes of Level: Strongly Disagree=1; Disagree=2; Neither Agree nor Disagree =3; Agree=4; & Strongly Agree=5.

The results in Table 3 also clearly indicate that teachers do not strongly agree with the idea that VR and AR save study and research time (Q3, mean = 3.00) and save costs compared to other learning tools (Q4, Mean = 3.22). Additionally, teachers have not yet realized that using VR and AR can promote social interaction and collaboration (Q7, Mean = 2.88).

B. Discussion

1) Assessment of teachers on the current usage of VR and AR technology in teaching

This paper based on the data tables regarding the survey results of actively teaching educators, we can conclude that there are numerous advantages to using VR and AR technology in education. However, teachers also face several challenges when integrating VR and AR into their teaching. One of the difficulties is adjusting lesson plans to align with VR and AR applications [41]. Teachers also need to adjust their teaching methods when using AR in education [42]. In Vietnam, several factors can influence the adoption of VR and AR technology in education, Specifically:

Firstly, it is evident that there are varying degrees of technology usage among educators. While some have been using computers and smartphones for over a decade, others have only recently started using them. This suggests that differences in familiarity and comfort with technology could influence the adoption of VR and AR in teaching.

Secondly, the research indicates that workplace location affects the availability of internet infrastructure. Teachers in urban areas have better access to computers and smartphones for instructional support compared to those in rural and mountainous areas. This reaffirms that work location and internet infrastructure have an impact on the effectiveness of integrating VR and AR technology into teaching.

Thirdly, there seems to be a correlation between educational attainment and duration of technology usage. Those with higher education levels tend to use technology for long periods. This suggests that educators with lower educational backgrounds might need additional support to integrate VR and AR technology into their teaching practices.

Lastly, there is a correlation between English language proficiency and technology usage. Those with better English language skills tend to use technology for long. Interestingly, some respondents reported average or low English language skills but had used computers and smartphones for an extended period, over ten years. This result led the research group to make qualitative assessments: The English language proficiency of teachers does not significantly affect the use of VR and AR technology for teaching. This demonstrates that language might not be a significant barrier to the adoption of these technologies in education.

The results found in teachers' assessments of the current usage of VR and AR technology in teaching are consistent with the results of S. Tzima *et al.* [43], in which the use of VR and AR also requires teachers to possess a certain level of technological knowledge. Teachers' evaluation of internet infrastructure is also relevant to the results found by Dyulicheva [42], it is also indicated that the availability of teaching devices also impacts the use of AR in teaching. This research indicated teachers' extent of technology usage for instructional support is correlated with job positions, work locations, expertise levels, and internet infrastructure, and English proficiency influences the ability to use smart devices can effectively utilize VR and AR in education. The extent of technology usage for instructional support is correlated with job positions, work locations, expertise levels, and internet infrastructure. However, the English language proficiency of the participating teachers does not significantly impact the use of VR and AR technology.

2) Analysis of teachers' evaluations of the role of VR and AR in Vietnamese education

In Vietnam, there have been some studies on the use of VR and AR technology in education, such as simulating 3D chemical compounds [18] and simulating intangible cultural heritage [20]. However, there has not been any research on the desires or preferences of teachers regarding the use of VR and AR technology in teaching. Valuation result from teachers confirms that they hold a favorable high qualitative evaluation of the role of VR and AR in education. The results found in teachers' attitudes toward the AR tool are consistent with the results of Jdaitawi *et al.* [34], who found factors to confirm the importance of augmented reality technology in science education. Furthermore, in Khan *et al.* [22], it is also indicated that the impact of an augmented reality application on the learning motivation of students.

However, the quantitative assessments of the benefits of VR and AR in education show that teachers do not fully comprehend the underlying roles of VR and AR in education, which may be linked to the level of experience and the depth of teachers' familiarity with integrating technology into education. This evaluation result from teachers is consistent with the results of Nguyen [20], it indicates the motivations and barriers to embracing augmented reality.

This paper indicated that, despite being introduced to this technology through the process of building virtual experiments, molecular structure models, and images, they still require further research to assess the role of this technology quantitatively and rigorously in developing students' abilities at different educational levels. This result is also consistent with the results of A. D. Rahmat et.al, the study found that many teachers had less knowledge of AR technology because they had experienced it for the first time. However, they were highly interested in implementing the technology in science learning after exploring its use independently [44]. As a result, this orientation could guide further research in the application of VR and AR in education, providing a more comprehensive and quantitative evaluation of the role of this technology in developing students' capabilities across various educational stages.

3) Propose solutions

Drawing upon research findings concerning the integration of VR and AR technology into secondary and tertiary education in Vietnam, we can propose a series of strategies aimed at optimizing the educational utility of this technology:

Investment in Infrastructure and Resources: Educational institutions should allocate resources towards establishing the requisite infrastructure for implementing VR and AR in teaching. This involves procuring necessary equipment like headsets, VR glasses, and associated software tools. Furthermore, prioritizing comprehensive training for educators in leveraging and maximizing this technology within the teaching process is imperative.

Development of Educational Content: Facilitating the creation of educational content and learning materials utilizing VR and AR is of paramount importance. Educators and researchers can collaborate to produce lectures, practical exercises, and interactive activities through this technology. This enhances student engagement and interaction during the learning journey. The emphasis should be on crafting substantial, application-oriented VR and AR learning content that aligns seamlessly with the curriculum.

Ensuring Access for All Learners: Ensuring universal access to VR and AR technology is pivotal. Schools can contemplate dedicating specialized classrooms furnished with VR and AR devices, thereby allowing students to partake in activities employing this technology. Additionally, extending the incorporation of this technology to public educational centers and external learning institutions should be explored.

Empowering Educators through Training: Committing to educator training in the utilization of VR and AR for teaching is a critical endeavor. This involves furnishing educators with a comprehensive understanding of the technology, its effective employment, and the creation of captivating virtual learning materials. Crafting tailored training programs to enable educators to seamlessly integrate this technology into their daily teaching routines holds significance.

Fostering Interdisciplinary Research and Development: Cultivating collaborations between the education and technology sectors to investigate and develop VR and AR applications for teaching and learning is indispensable.

In amalgamation, these strategies can significantly harness the potential of VR and AR technology in the realm of education. They engender captivating and immersive learning experiences that redound to the benefit of both learners and educators.

V. Conclusions

The paper concludes that while VR and AR technology have been widely applied in education, their adoption in Vietnam is still limited. The study analyzes the factors influencing the application of VR and AR in teaching and the perceptions of teachers regarding their role in education. The obtained results confirm that there are four key factors influencing the adoption of this technology in teaching. The factor of English language skills of teachers does not affect the awareness or utilization of this technology in teaching. The research outcomes have illuminated the potential benefits that this technology brings to the teaching and learning process. It indicates that VR and AR can bridge the gap between theoretical knowledge and real-world application, enhance conceptual understanding, improve information presentation in 3D and 4D interactive experiences, and facilitate practical learning. The paper suggests that further research should propose measures to enhance the use of VR and AR in science education in Vietnam, explore their integration into teacher professional development programs, and address the challenges and limitations associated with their implementation. Especially, emphasis is placed on leveraging the roles of VR and AR in enhancing students' learning outcomes. They provide students with opportunities to transform abstract concepts and complex subjects into more accessible and understandable forms. They facilitate easy exploration of virtual environments, interaction with objects, and simulation of real-life scenarios. This helps them develop practical skills and enhance problem-solving abilities, offering valuable opportunities for hands-on and real-world learning, and preparing students to tackle future professional challenges.

The paper suggests the way of the untapped potential residing in the integration of VR and AR technology within teacher training initiatives. Furthermore, it advocates delving into the ramifications of prolonged exposure to VR and AR on students' learning and retention. It proposes the execution of comparative studies to gauge the comparative efficacy of VR and AR technology against traditional teaching methodologies in distinct educational landscapes. Lastly, the paper recommends an examination of obstacles and impediments that might impede the widescale adoption of VR and AR technology in science education in Vietnam, and the formulation of strategies to surmount these challenges.

However, we recognize certain limitations in this study. The research lacks a thorough examination of constraints inherent in the utilized methodology, including potential biases in survey responses and limitations related to qualitative analysis tools like NVIVO. In addition, intrinsic limitations of VR and AR technology, such as financial implications, technical constraints, and the need for specialized teacher training, are not fully addressed.

Moreover, there is insufficient exploration of limitations regarding sample size and participant representation. The study involves 427 educators across various educational levels in Vietnam, overlooking potential constraints. The paper also neglects to discuss possible limitations linked to the introduction of VR and AR in science education, including the need for specific equipment, potential resistance among students and educators, and the learning curve associated with this technology.

Furthermore, the paper does not acknowledge constraints related to generalizing findings to different educational settings or countries. The focus remains confined to the integration of VR and AR in the Vietnamese educational landscape, limiting its broader applicability.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Vu Thi Thu Hoai conducted the research, analyzed data, and wrote the manuscript. The authors collaboratively construct the content of the article. All authors had approved the final version.

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