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Application of augmented reality technology in education in Vietnam: Current situation and solutions

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Abstract
Augmented Reality (AR) technology has significant potential and advantages for the teaching and learning process due to its interactive and immersive nature. Within the scope of this topic, the research group focuses on investigating the trends of using augmented reality technology in education to determine the extent and scope of its utilization in teaching at primary and secondary schools in Vietnam. Additionally, the group proposes solutions and directions for development to apply AR in education. The study employs qualitative and quantitative analysis methods, including surveying 678 students and 328 lecturers and teachers from secondary, high school and tertiary institutions nationwide. The survey results indicate that the use of AR technology in Vietnam's primary and secondary education system is still quite limited and not widely implemented, as traditional teaching methods remain predominant. However, considering the potential and benefits that AR technology brings, its application in education can open up a new and promising future for education.

Introduction
In the current digital age, the application of technology in education has become increasingly necessary and undeniable, emerging as an undeniable trend [1]. Among these technologies, Augmented Reality (AR) stands out with its numerous outstanding features that have demonstrated their power when applied in education [2].

AR create a unique and creative learning environment that is completely different from traditional learning methods. It allows the creation of interactive, dynamic, and engaging learning environments, enabling students to imagine concepts that were once confined to textbooks, thereby gaining a deeper understanding of the lessons. Students can directly interact with virtual objects displayed in the real world, ranging from viewing 4D images, graphics, and simulations to conducting virtual experiments and interacting with dynamic models, helping them grasp the lessons in a visual and in-depth manner, thus generating enthusiasm during the learning process [2].

The application of AR also brings new opportunities and challenges for teachers and students by focusing on exploring the use of AR to enhance the effectiveness of the teaching process, overcoming difficulties in knowledge transmission, and exploring new opportunities in the learning process [3]. The use of augmented reality products provides teachers with the ability to create AR-based materials, products, or games that align with the teaching content, thereby enhancing student interaction and engagement, and providing conditions for acquiring knowledge that is suitable for various student profiles.

In addition, augmented reality products are highly suitable for supporting remote learning due to their flexibility. Students can learn anytime and anywhere, allowing them to connect and study from any location worldwide. This creates opportunities for students and teachers to not only interact and collaborate remotely but also share information, ideas, and outcome through specially designed AR applications that cater to various forms of learning [4].

In the context of teaching, AR products have brought about an immensely engaging learning environment. However, augmented

reality products have not been widely adopted in Vietnam. Therefore, we have conducted a research project titled: "Application of Augmented Reality Technology in Education in Vietnam - Current Situation and Solutions."

Literature Review
Augmented Reality (AR) is a technology that allows users to interact with a virtual environment through intermediate devices such as smartphones, tablets, or AR glasses. AR has undergone a long development process from the 1960s until today, spanning various industries and fields, including military, healthcare, commerce, and education [5]. AR, which evolved from Virtual Reality (VR) technology, has quickly become a focal point of development for technology giants in the industry.

The first virtual reality system, called "The Sword of Damocles," was invented by scientist Ivan Sutherland. It allowed users to interact with virtual objects using a controller and paved the way for the development of multimedia content such as images and sounds… [6]. However, it wasn't until the 1990s that the term "Augmented Reality" officially emerged and was used by computer service engineers at Boeing, Thomas Caudell, and David Mizell. They described the use of integrated display technology in headsets to provide information to craftsmen working on complex aircraft details [7]. During that time, Thomas B. Sheridan also introduced the concept of "Virtual Fixtures" - virtual objects in the augmented reality environment that assist users in performing specific tasks [8], highlighting the potential of this new technology.

In the late 20th century, augmented reality technology experienced significant development, marked by the event of the company ARToolworks creating the open-source software ARToolKit. This allowed developers to create augmented reality applications on various platforms. Building on the success of ARToolKit, the first widespread AR application was launched on the iPhone, enabling users to use the phone's rear camera to interact with virtual objects on the screen [6].

Currently, augmented reality (AR) is a technology with a significant impact in various fields such as entertainment, commerce, industry, healthcare, and education, accessible through a wide range of devices [1]. In education, AR is considered a "new strategy" to enhance learning capabilities compared to traditional methods [9]. It can be applied across diverse subjects and different educational levels, including mathematics [10], science [11], programming [12], and more, thereby positively impacting learning outcomes.

Numerous researchers worldwide have studied augmented reality applications in education, including Sirakaya [13], Kerawalla [14], Lin Y. [15], Cai S. [16], McMahon. [17], Küçük [18], and others. Their work has received positive feedback from experts, and there are influential articles on AR, such as "Setting the future of digital and social media marketing research: Perspectives and research propositions" by Dwivedi *et al.* (2021) with 658 citations and "Virtual laboratories for education in science, technology, and engineering: A review" by Potkonjak *et al.* (2016) with a total of 440 citations.

The first augmented reality (AR) applications were introduced in Vietnam in 2010, primarily in the fields of education and entertainment. However, due to limited technology and internet accessibility, AR remained relatively unknown to many people.

Subsequently, in 2016, during the period of significant growth in mobile devices, the market for AR development opened up and gained much attention. Many companies and organizations began investing in and developing AR for various purposes.

Since 2018, the application of this new technology in education in Vietnam has garnered significant attention. Numerous studies have been conducted on the impact of AR on the learning process, including notable research by authors such as Nguyen Mau Duc on the application of AR to develop self-learning abilities for students [19], Nguyen Thi Thanh Tu on the application of AR in the form of Microlearning for online learning [20], Thai Hoai Minh and Nguyen Minh Tuan on enhancing learning interest [21], and Pham Kim Chung on 4D interaction in natural science subjects [22]. These studies have surveyed and researched the current use of AR in education to find solutions for the development of teaching and learning quality.

In addition, the application of AR in educational training in Vietnam has received significant attention across various educational levels. For example, Vinschool elementary schools have integrated AR into their textbooks. Marie Curie High School in Ho Chi Minh City utilizes AR in teaching activities conducted by teachers. Ho Chi Minh University of Education and Technology incorporates AR into their teaching and practical instruction for students.

As part of the "Learning for Children" project between the Ministry of Education and Training, UNICEF, and the Center for Family Health and Community Development (CFC), a training workshop titled "Applying Augmented Reality in Education" was organized for teachers, specialists, and educational leaders from schools and education departments in Lao Cai province [23]. Since the beginning of the 2019-2020 academic year, FPT Middle School and High School have implemented AR in their regular classroom lessons, where teachers utilize prepared tools to incorporate augmented reality technology, resulting in positive feedback. [24]

In particular, in 2019, the Institute of Information Technology and Communication (ICT) in Vietnam collaborated with a leading partner in Japan to organize an AR training course to equip application developers with the necessary skills, knowledge, and trends in AR development [25]. Additionally, the information technology industry in Vietnam has been experiencing strong growth, with major companies such as FPT, VR Tech, Hachinet Software, etc., showing interest and developing augmented reality products for educational purposes, which can be easily accessed through smartphones. The reality is that smartphones are becoming increasingly popular.

It can be seen that with the emergence of numerous research studies, articles, surveys, and the interest and investment of major companies, augmented reality (AR) technology remains a top priority in Vietnam and is considered one of the key technology trends in education.

However, the widespread implementation of AR in Vietnam is still a challenging task. Building AR content in education requires specialized knowledge and programming skills. Additionally, the advanced nature of the technology presents difficulties in application accessibility, as it requires time to explore and understand how to use it effectively. Therefore, alongside the development of augmented reality products for educational purposes, it is essential to create comprehensive accompanying teaching materials. The authors need to have

pedagogical knowledge to effectively convey information and understand the target users in order to create high-quality training products. This way, learners can access and utilize the materials to enhance the effectiveness of their training.

Methodology
A. Sample and data collection
Sample size: Based on the research by Hair, Anderson, Tatham, and Black [26] as a reference for the expected sample size, the minimum sample size should be five times the total number of observed variables. This is an appropriate sample size for studies using factor analysis [27], n=5*m, where m is the number of questions in the survey.

In this study, the research team determined a sample size of 1006 participants, including 678 students and 328 teachers in Hanoi, Thai Nguyen, Nghe An, and other provinces, following the guidelines set by Comrey & Lee [27].

B. Data Collection Process
We conducted a literature review to guide and provide a theoretical foundation for the research team to approach the topic and develop a survey questionnaire on the current status of AR applications in education in Vietnam. Subsequently, the research team employed a survey method using online data collection. In the survey questionnaire, we utilized a combination of closed-ended and open-ended questions to gather comprehensive and objective information. Closed-ended questions were used for basic surveying and designed in the form of multiple - choice questions, with respondents required to select one or multiple options. Some questions were designed as Likert scale statements and open-ended questions were used to collect participants' opinions.

- Reference materials: This method is based on information collected from reference materials, including books, articles, and previous studies on the application of augmented reality (AR) in education. Searching for reference materials helps the research team gain a better understanding of important aspects and directions in this field.
- Survey method: The research team created a survey questionnaire using Google Forms and distributed it to students and teachers. This method not only helps save costs but also is convenient for both researchers and participants, allowing for a larger sample size compared to interview methods.researchers. Naturally, data on viewers is required to determine the impression of video news thumbnail updates that have propagated through YouTube.

C. Method of data processing and analysis
- For qualitative data collected from the study: The data is collected in the form of information. The process of analyzing the data is divided into 3 steps: Data coding, creating information groups, and connecting the data.
- For quantitative data collected from the study: The data is collected in numerical form. After collecting the data, the research team proceeds to clean the data, encode and input the data into SPSS software. The ANOVA software is used to process qualitative analysis data, and SPSS 26 software is used to process data for values such as standard deviation (S), dependent t-test (p), and effect size (ES).

Results and Discussion
Survey Results from Teachers
We conducted a survey of 328 teachers in Hanoi, Thai Nguyen, and Nghe An, and obtained the following results: Survey results on teachers' opinions about the application of AR in practice.
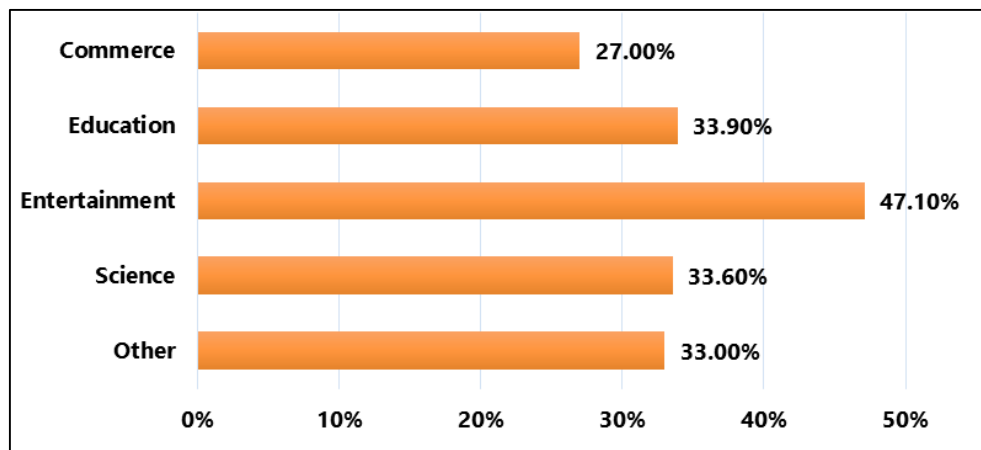

Fig 1: Applications of AR in practice in Vietnam

As shown in Figure 1, Augmented Reality (AR) technology is creating numerous practical opportunities in various industries in Vietnam, ranging from education (33.9%) and science (33.6%) to entertainment (47.1%) and commerce (27%), providing engaging experiences and enhancing work efficiency. In addition, we surveyed the benefits of using AR in education, and the results are as follows:
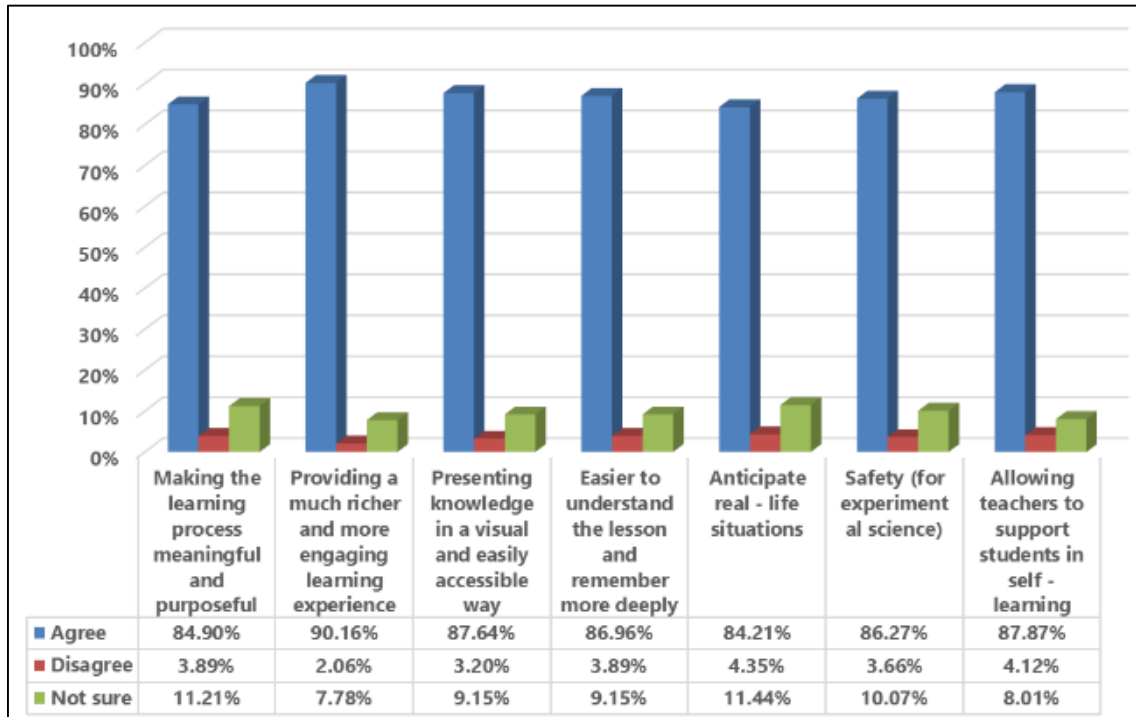
	Making the learning process meaningful and purposeful	Providing a much richer and more engaging learning experience	Presenting knowledge in a visual and easily accessible way	Easier to understand the lesson and remember more deeply	Anticipate real - life situations	Safety (for experiment al science)	Allowing teachers to support students in self - learning
Agree	84.90%	90.16%	87.64%	86.96%	84.21%	86.27%	87.87%
Disagree	3.89%	2.06%	3.20%	3.89%	4.35%	3.66%	4.12%
Not sure	11.21%	7.78%	9.15%	9.15%	11.44%	10.07%	8.01%

Fig 2: Benefits of using AR in teaching

Figure 2 has shown the benefits of Augmented Reality (AR) technology, such as: "Making the learning process meaningful and purposeful" (84.9%), "Providing a much richer and more engaging learning experience compared to delivering through books, websites, or even videos" (90.16%), "Presenting knowledge in a visual and easily accessible way" (87.64%), "Allowing teachers to support students in self-learning and computer manipulation" (87.87%). These findings demonstrate the advantages of this technology for the development of students when applied in the teaching and learning process.

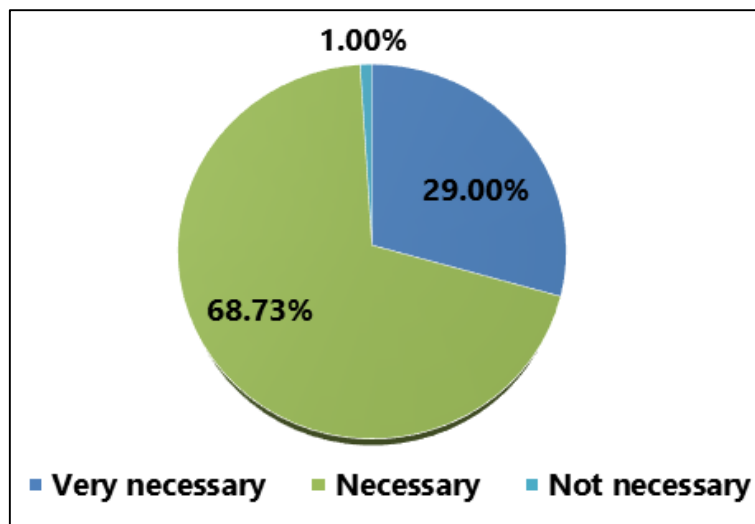Survey results on the necessity of AR in the teaching process:

Fig 3: The necessity of AR in teaching

The survey results show that 68.73% of teachers perceive that the use of AR in teaching is necessary, and 29.82% think that it is very necessary. Only 1.45% of teachers perceive that using AR in teaching is not necessary. The application of AR technology in teaching is receiving significant attention from teachers, and they are aware of the benefits it brings. As a result, the research team has assessed the current situation and the desires of teachers regarding the use of AR in teaching.

Survey results on the current situation of using AR in the teaching process are as follows:
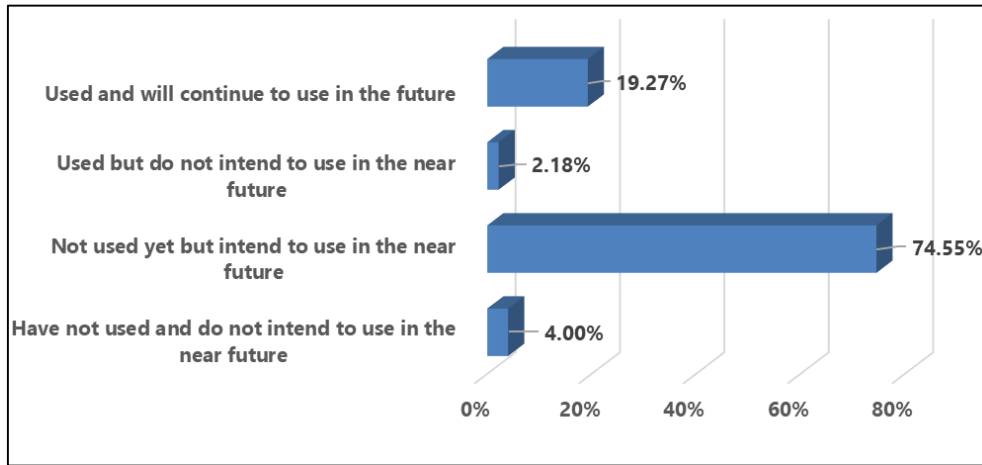
Fig 4: The reality of using AR in the teaching process

The survey results show that the majority of teachers have not yet applied AR in their teaching but have the intention to do so in the future, accounting for 74.55% of the total responses from teachers. The second-highest percentage, constituting 19.27%, indicates that some teachers have already applied AR and intend to continue using it in the future. Based on these results, it can be concluded that most teachers have limited exposure to AR due to the limited infrastructure. While some teachers have certain knowledge about AR, their awareness is still not complete. Therefore, the majority of teachers show their desires to apply AR in teaching, especially with the increasing popularity of the internet and the availability of various AR devices such as smartphones, computers, iPads, etc. The adoption of augmented reality products in education in Vietnam is gradually becoming a new trend.
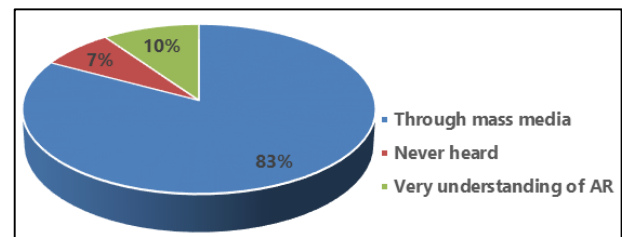
Survey Results: Students' Opinions
We conducted a survey on students' access to Augmented Reality (AR) technology and obtained the following results:

Fig 5: Access to augmented reality technology

Currently, the majority of students have access to Augmented Reality (AR) technology through various media channels (83%) and have a good understanding of AR (10%) which demonstrates their ability to quickly explore and enjoy the exciting experiences that AR offers. Additionally, most students are interested in information technology products, making the application of Augmented Reality technology in education entirely feasible.
Survey results indicate several benefits of AR in the learning process:

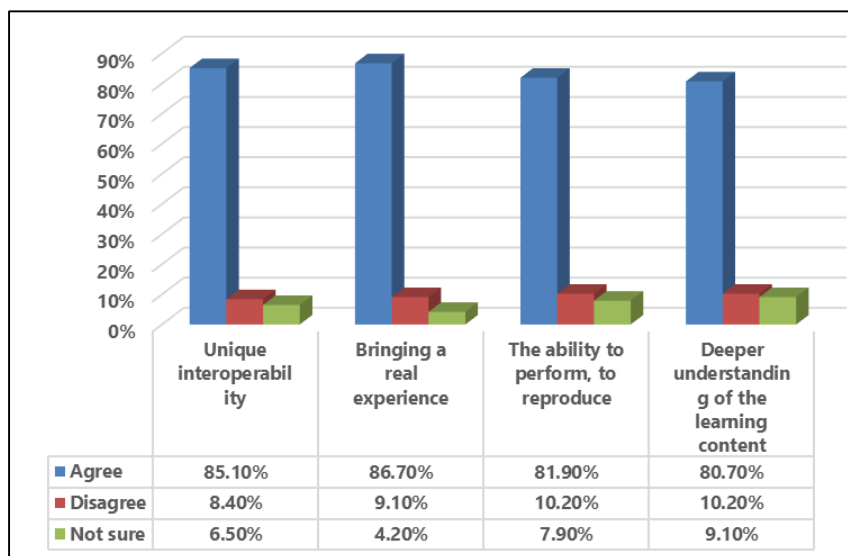|	Unique interoperability	Bringing a real experience	The ability to perform, to reproduce	Deeper understanding of the learning content
Agree	85.10%	86.70%	81.90%	80.70%
Disagree	8.40%	9.10%	10.20%	10.20%
Not sure	6.50%	4.20%	7.90%	9.10%

Fig 6: Benefits of AR

Augmented Reality (AR) technology brings numerous significant benefits in education, such as providing unique interactive capabilities that allow students to directly interact with learning content by creating and interacting with virtual objects on the screen (85.10%). It enables students to practice, explore, and apply knowledge in a creative and

active way through authentic experiences, allowing them to experience situations and environments that are almost realistic without physically being present at the location (86.7%), such as participating in a virtual tour to historical landmarks or geographical sites to gain a deeper understanding of the learning content (80.70%).

Moreover, AR has the ability to present and visualize complex concepts in a visual and vivid manner (81.9%). Students can see, explore, and interact with 4D models, charts, or graphics, helping them gain a clearer understanding of the structure, processes, or interactions of concepts in their respective fields of study.

In addition, we also surveyed some difficulties in the learning process of students, and the results obtained are as follows:
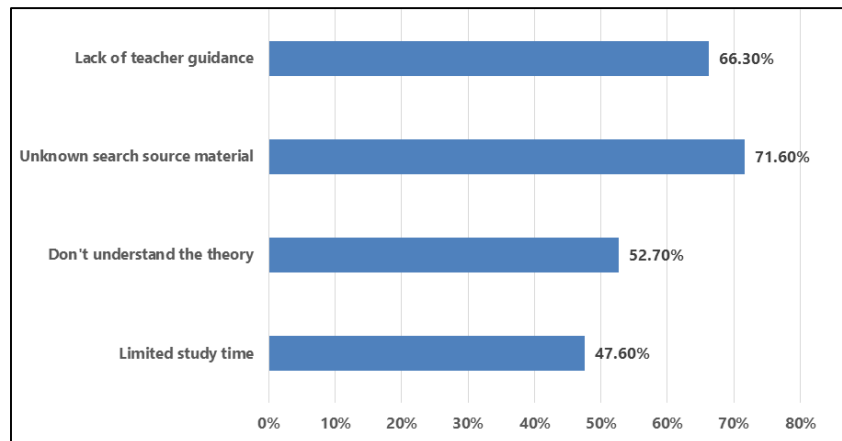

Fig 7: Difficulties in the learning process of students

During the learning process, students often encounter some difficulties such as limited classroom study time (47.6%) and pressure from assignments, projects, and personal activities. Additionally, students often struggle to understand the taught theory or concepts (52.7%) due to the high level of abstraction or complexity in certain subjects, making it difficult for them to grasp and apply them. Students require detailed explanations and illustrative examples from teachers to help them gain a better understanding and practical application (52.7%). When searching for information on the internet, students may also face challenges in finding suitable and reliable resources for their research and study assignments (71.6%). Augmented reality (AR) products are well-suited to address these limitations as they can be conveniently used anywhere, anytime, with self-learning guidance designed within standardized and carefully selected knowledge materials by teachers. The aforementioned benefits highlight the important roles and practical relevance of the topic when applied in practice in Vietnam.

Regarding the level of AR usage in student learning, we obtained the following results:
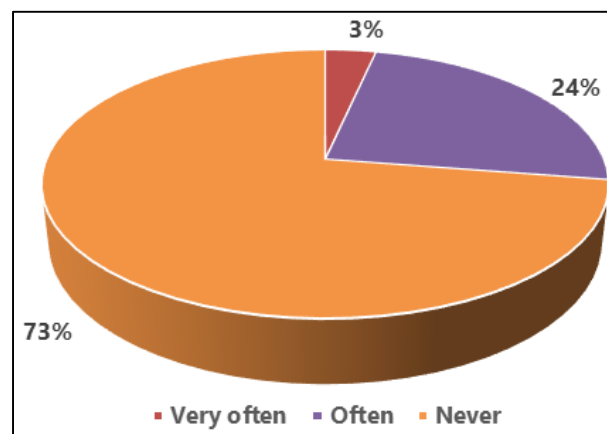
Fig 8: Level of using AR in learning by students

Although students have been exposed to Augmented Reality (AR) technology, the utilization rate is still limited due to the lack of widespread availability of AR products. As a result, many students have not had the opportunity to use AR (73%), only occasionally (3%), or have merely observed it through videos (23%). However, with the advancement of technology and the emergence of numerous AR applications on commonly used mobile devices such as smartphones and tablets, the use of AR in education has the potential to grow and become more prevalent, offering students greater opportunities for creativity and interaction.

General Comments
Based on the gathered information, we would like to make the following observations regarding the application of AR in teaching and learning in Vietnam:
- According to the research, 33.9% of teachers agree that AR has many benefits in the field of education,

indicating the acceptance and adoption of this technology in the education sector.

- Additionally, 68.73% of teachers agree that the application of AR is necessary in education. This demonstrates the awareness of teachers regarding the potential and benefits of AR in enhancing the quality of teaching and learning.
- There are numerous benefits that AR brings to education, allowing teachers to create an interactive and engaging learning environment, while assisting students in acquiring a deeper understanding by enabling them to interact with 4D objects and visualizing knowledge. Therefore, AR helps enhance the interaction between teachers and students, creating a multidimensional learning environment and encouraging active participation of learners.
- Despite significant progress, the implementation of AR in education still faces some challenges, as the majority of teachers have not had the opportunity to utilize this technology. However, 74.55% of the total responses from teachers indicate their intention to apply AR in the future, showing that some teachers are actively considering and planning to use this technology continuously.
- Regarding students' access to AR, it can be seen that the majority of students have been exposed to this technology through various media, accounting for 83% of the total. This indicates that AR is no longer unfamiliar to students. However, only 10% of the total responses indicate that students have a strong understanding of AR, highlighting the need for guidance and further education on AR for students to fully leverage its potential in the learning process.

Proposed Measures

To facilitate the application of Augmented Reality (AR) technology into teaching more easily, the research team proposes the following measures:

- AR for teachers and educational administrators. This helps them gain a clear understanding of AR technology, how to use it in the teaching process, and develop appropriate AR content.
- Building and provide readily available AR materials, applications, and content for teachers to use in their teaching. This helps teachers save time and effort in creating AR content from scratch.
- Creating a collaborative environment and share experiences among teachers, schools, and educational organizations. This helps leveraging successful experiences and available resources to create better AR experiences in teaching.f
- Improving technology infrastructure, including internet connection and supporting devices, to provide convenient conditions for applying AR in education. This ensures that both teachers and students can access and use AR easily.
- Ensuring equitable access to Augmented Reality (AR) technology for students is crucial. Governments and educational institutions need to set goals and measures to reduce technical and financial disparities while ensuring that all students have the opportunity to experience AR in their learning process.
- Designing interesting activities and challenges that

utilize AR technology in teaching to stimulate students' interest and motivation. This enhances interaction and creative thinking among students during the learning process.

- Encouraging continuous research and development in the application of AR in education. This helps generating improvements and enhancing the quality of AR implementation in teaching.

Therefore, the application of AR in teaching becomes easier when investing in training, resources, technology infrastructure, collaboration, and experience sharing. This fosters interest and motivation, along with ongoing research and development in this field.

Conclusion

Survey and investigation results have shown that the application of AR in education in Vietnam has been implemented in a creative and flexible manner, although it has not been widely adopted. These results have highlighted the benefits that AR brings while also pointing out the challenges in implementing AR in learning. Additionally, both teachers and students are eager to use AR in the learning process. Therefore, the research group proposes measures recommendations to facilitate the integration of AR into teaching. With the benefits that AR brings to education, the implementation of AR in teaching is an inevitable trend to provide students with new and exciting learning experiences while promoting the development of education to meet the demands of the new era.

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