# Augmented Reality in Virtual Graphic Design Education: Engagement and Learning Outcomes

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**Abstract.** This study investigates how augmented reality (AR) technology can be integrated into the teaching of graphic design at Greenwich Vietnam in response to the educational demands of the Industrial Revolution 4.0. Conducting a mixed-methods research design, the study combines quantitative survey data from 164 students with qualitative data analysis. The findings indicate that AR-enhanced learning environments improve student engagement, conceptual visualization, and interactive exercises. It also significantly improves student engagement, conceptual visualization, and interactive exercises. Students' concentration and participation rates, conceptual visualization, and interactive exercises increase. A framework for incorporating AR into graphic design e-learning is proposed. It centered on fundamental components such as interactive module design, learner feedback, and instructor training. It seeks to facilitate the sustainable advancement of immersive digital learning environments within higher education contexts.

**Keywords:** augmented reality, e-learning, sustainable education, student engagement.

## 1 Introduction

Today, the rapid development of digital technology in the era of the Industrial Revolution 4.0 promotes the transformation and shaping of the higher education landscape. Many educational institutions are rapidly adopting innovative approaches to teaching and learning. Among them, online learning has emerged as a key method to help training institutions have more flexibility in expanding geographical and temporal boundaries for learners. In Vietnam, the development of online education is receiving much attention from educational institutions to implement the national digital transformation strategy. This development is rapidly promoting the application of virtual learning environments. Although online platforms allow training institutions to access education more widely, they often fail to adequately meet the participation of learners, as well as the interaction and development of practical skills among students. Recent studies have shown the potential of augmented reality (AR) to address some of these limitations by providing learners with immersive experiences through virtual classroom interactions and also motivating them to engage in the learning process and practice. By visualizing theoretical frameworks, AR allows learners to visualize abstract concepts easily as well


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as interact with 3D content and engage in hands-on simulations. Thus, it enhances both cognitive and affective learning outcomes. Although the applications of AR in online classrooms are growing and promising, especially in creative disciplines such as graphic design, they are still underexplored, multifaceted, and therefore have potential limitations. Current research often focuses on technical feasibility or pilot implementations, with little attention paid to pedagogical implications and the perspectives of both learners and teachers. This study seeks to fill that gap by using a case study to critically examine the integration of AR into graphic design education in online virtual classrooms in Greenwich, Vietnam. Specifically, this study investigates how AR affects student engagement, content retention, collaborative learning, and their experiences in the virtual environment. Through the analysis of empirical data and educational practices, this study aims to contribute to the assessment of the role of AR in enhancing digital learning experiences in higher education, especially graphic design education. This research paper focuses on answering the research questions: How can we apply augmented reality (AR) in virtual classrooms to enhance student engagement and interaction? And what are the main issues and opportunities that arise when using AR technology for online learning in higher education?

## 2 Literature review

Today, the rapid development of technology has been changing every field of society, including education. In particular, VR, AR, software tools, and the metaverse are changing the way people teach and learn in the field of graphic design education (Yun-Tzu Tien, 2024).

Moreover, the use of technology enhances the learning experience and equips students with the necessary skills to work in a digital design environment (Katz-Buonincontro et al., 2025). Photoshop, Illustrator, and InDesign are all part of the Adobe Creative Suite. Digital graphic design classes now commonly use Blender and Cinema 4D, two 3D tools (Meggs & Purvis, 2016). Lupton et al. (2011) argues that the use of digital tools for art and design education will help students become familiar with professional tools while they are still in school. This will help students transfer their design skills from school to the real world. A variety of tools—including learning management systems (LMS), professional design software, and immersive technologies such as virtual reality (VR), augmented reality (AR), and hyperspace platforms—have been developed to enhance pedagogy; however, a critical synthesis is needed to understand the integration of these tools into educational theories and learning models.

The implementation of e-learning in the metaverse is rapidly shaping a new training trend for graphic design education. According to (Manpreet Arora, 2024), teaching in the metaverse environment allows students to attend virtual classes, work in digital design spaces, and collaborate in groups. In addition, they can also exchange discussions and receive real-time feedback from instructors. Popular platforms such as Spatial.io and Meta Horizon Workrooms provide flexible learning spaces that help students strengthen their design skills in a completely digital environment (Sinfield, 2013). By integrating AR and VR, educators have provided more interactive and intuitive ways

to teach graphic design. According to Mayer (2021), VR allows students to experience three-dimensional design spaces. It helps learners develop digital design models. Students can create graphic design products in virtual space using tools like Tilt Brush and Gravity Sketch. These digital tools encourage them to be more creative and interact with design products in new ways (Hoppe et al., 2003). New technologies, such as Spatial.io or Meta Horizon Workrooms, have begun to facilitate more immersive e-learning classrooms. Kelly (1996) argues that the metaverse offers new forms of presence and interaction; however, its applications in the educational field are still not widespread and there is still a lack of objective and comprehensive evaluation research. Furthermore, augmented reality tools such as Tilt Brush, Gravity Sketch, and mobile AR viewers provide three-dimensional interactions, thus reinforcing the theory of experiential learning (Kolb, 2014), which argues that knowledge is acquired through the transformation of experiences (from physical experiences to experiential, emotional, reflexive, and cognitive experiences).

With the many advances and highlights of technology, current studies often have an optimistic view of technology and emphasize benefits such as increased motivation, engagement, and creativity (Fleischmann, 2024). However, they do not seek to seriously address the limitations of technology application in education. Such as the issue of digital fatigue of learners in technological environments (Shah, 2023), or the technological inequality among members of the classroom. Such as the rights of those with access to powerful hardware devices (high configuration) or stable internet connections. Technology overload due to novelty effects has not been fully explored in a short time. Furthermore, core pedagogical concepts—such as "engagement," "interactivity," and "learning experience"—are frequently mentioned but rarely defined or operationalized. Based on Singh et al. (2022), student engagement should be understood as a multidimensional construct that includes behavioral, emotional, and cognitive dimensions, each of which may be affected differently by AR-enhanced environments. This study applies the SAMR model (Blundell et al., 2022) as a conceptual framework to systematically and multidimensionally examine, analyze, and evaluate the functions of AR in improving the learning experience in e-learning. This framework classifies technology integration into four levels: replacement, enhancement, modification, and redefinition. This study posits that augmented reality (AR) functions not merely as a substitute for traditional educational content but also as a transformative agent that facilitates novel modalities of visual, spatial, and collaborative learning, previously unattainable through conventional or digital methods. This framework allows for a critical analysis of how AR changes the nature of learning tasks and outcomes. This study contributes to the field by anchoring AR implementation within established educational theories and the SAMR framework while also considering the specific capabilities and limitations of AR to promote engagement and interactivity in virtual classrooms.

Technology supports the PBL approach to help students apply knowledge to real-world projects. According to Fine (2016), PBL combined with design software and online collaboration tools helps students develop problem-solving, creative thinking, and teamwork skills. According to the constructivist perspective (Schimmelfennig, 2013), learners actively construct knowledge through interactions with content, peers, and their environment. AR, in particular, is emerging as a tool to support experiential

learning. It builds learning environments by allowing students to interact with and edit digital images in a convenient, efficient, and immediate manner. Therefore, it has the ability to digitize and visualize abstract concepts, and connect these abstract concepts to tangible experiences. Mayer's (2021) cognitive theory of multimedia learning helps us better understand how AR can be effectively applied in educational settings. However, the possibility of cognitive overload of learners in immersive environments is a major concern when implementing AR technology in educational settings. Because the technology can distract learners with many novel features of the technology instead of focusing on the learning content itself (de Jong, 2010).

In Vietnam today, technology has been changing the way digital graphic design is trained. From professional software or LMS systems to AI and AR/VR, they are used to apply to the teaching and learning process. Up to now, Vietnam has had many scientific studies on the application of augmented reality technology in education to increase students' interest in learning, thereby improving teaching efficiency and effectiveness. In the graphic design industry, augmented reality technology has become familiar to students through exhibitions and art projects such as “SaiGon Co Mua” (Van Nghe, 2018), “Urban Layers” (Mensfolio, 2021), “Bring Them Back” (Mai Anh, 2022),... In recent years, the number of graduation projects of graphic design students applying augmented reality technology at Greenwich University Vietnam, Ho Chi Minh City campus,, has increased significantly. In general, the application of augmented reality technology has been applied in high school blocks; however, augmented reality has not yet been applied to university curricula even though university students have a familiar background with this technology. To strengthen the learning experience of graphic design students, two-way interaction between teachers and students needs to be thoroughly implemented in real time. Therefore, research on 3D web applications, augmented reality, and gamification should be optimally applied to education in general and art education in particular to enhance the interactive and immersive features of the learner experience. The current situation of art design training institutions in Vietnam applying virtual classrooms in graphic design. At present, the ability to update and apply virtual reality technology in teaching and learning at universities training in graphic design has not been widely popularized. The main reasons we consider are investment costs, economic conditions, and facilities of domestic universities. In terms of training programs and teaching resources, we do not consider these to be obstacles to this form of training. RMIT Vietnam is said to be catching up with the trend by accumulating experience in VR, AR, and MR. This is thanks to RMIT Vietnam’s state-of-the-art Mixed Reality Lab—a multidisciplinary environment that allows students to research and develop virtual reality, augmented reality, and mixed reality projects. The Department of Design at RMIT Vietnam is very focused on how important it is to include mixed reality in all of their design programs because they think there will be a big need for these skills very soon (Hoang Ha, 2017). Each student comes up with alternatives; some create a therapy simulation, others make a game, or explore more about visual arts. As a result, upon graduation and entering the workforce, students will possess enhanced skills and exposure to cutting-edge technology. The Augment application allows students to transfer images of 3D models to their mobile phones through augmented reality (AR) technology. Ondris Pui commented, “Expressing ideas in a 3D

animated environment with text and sound makes design more engaging for students. Companies can also use this technology for presentations and interactive campaigns" (Sharon Webb, 2016).

## 3 Methodology

This study uses a mixed methods approach. By combining quantitative and qualitative techniques to explore the integration of technology - augmented reality (AR) in graphic design education, a case study at the University of Greenwich Vietnam. The rationale for using a mixed design is to combine different types of data to make the results more reliable and valid by considering both measurable trends and detailed opinions.

Based on the total number of students majoring in Greenwich Vietnam, the study surveyed 164 students majoring in graphic and digital design. The analysis results have a confidence level of 95% with a margin of error of 5–7%. The study uses stratified random sampling to ensure representativeness on key demographic information such as students' gender, year of study, and previous experience with AR or digital design tools.

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The survey questionnaire comprised 25 questions with a Likert scale ranging from 1 (disagree) to 4 (strongly agree). The questionnaire aimed to assess students' efficacy, engagement, interactivity, and obstacles associated with the usage of augmented reality in the classroom. A pilot research involving 20 students was undertaken to enhance the survey items for the graphic design student demographic. The survey scale had strong internal consistency, evidenced by a Cronbach's alpha coefficient of roughly 0.86.

To complement the quantitative findings, data for qualitative analysis was collected from interviews as well as through document analysis such as: course syllabus, student projects and reports, Greenwich Vietnam policies. Braun and Clarke's (2006) six-step process was also applied to thematically analyze the qualitative content. The theme draws on data to identify patterns in how AR is used in teaching, the challenges that educational institutions face when using it, and potential future opportunities...

In addition, the study analyzed content by reviewing academic literature, government education policy documents, and training institution reports on the use of technology in art and design education. This can contextualize the broader Vietnamese digital education research and global activities on immersive learning.

Both types of data (quantitative and qualitative) are collected and analyzed separately, then compared in the interpretive analysis and discussion phase. To ensure academic rigor, transparency, and practical relevance, this study links the empirical findings to theoretical models of educational technology and experiential learning. The study also highlights both the pedagogical potential and challenges in implementing augmented reality in the context of design education in Vietnam.

# 4 RESULTS AND DISCUSSION: A CASE STUDY AT GREENWICH VIETNAM

## 4.1 Level of access to e-learning in teaching

A case study at Greenwich Vietnam was conducted using a survey of 164 students from the Ho Chi Minh campus who have been exposed to and used augmented reality (AR) technology. Generally, most students gained their exposure to and experience with augmented reality through exhibitions and smartphone applications. A small number of the student community said that the application of AR provided a normal experience, sometimes causing eye strain and slowing down the process of receiving information; the majority of students agreed that the experience with augmented reality brought a sense of fun and excitement. Complicated and difficult to set up, some students had a challenging time building and using AR technology in their projects. Other graphic design students, however, claimed that AR could be created with ease using the appropriate software and websites.

Specifically, among the 164 students that participated in the study, 51.8% agreed and 15.2% strongly agreed that e-learning facilitated the enhancement of their design skills. This indicates that e-learning may serve as an efficient medium for imparting their digital design skills. The accessibility of e-learning in digital graphic design is evidenced by students' judgments of the impact of diverse educational methodologies on the enhancement of design abilities. The above data shows that the majority of students (67% in total) have a positive view of the application of e-learning in digital graphic design training. This may reflect the fact that there is a change in the perception of online education. AR offers a significant advantage in education by transforming conventional learning materials (text and static images...) into interactive, three-dimensional, or multimedia formats. Thanks to that, students can absorb knowledge more easily, especially in fields that require high visualization, such as graphic design. Students are increasingly accepting and recognizing the role of technology in developing professional skills when participating in online learning. In particular, new technologies such as VR/AR can help students practice design in a simulated space, bringing a learning experience closer to real work. They liked being able to use AR in their projects to

improve them for the intended audience. The results reflect students' interest in technology in the learning and content creation process. AR is now part of Greenwich Vietnam's training program. This gives students more ways to use technology in their creative work, which makes design projects more fun and interactive. Though over half of the total respondents agree. However, a significant proportion, 27.4%, were unsure, and 5.6% disagreed with this statement. This indicates that there are still concerns or limitations regarding the application of e-learning in training. The reasons for these concerns may include a lack of support tools, low interactivity, or teaching methods that do not fully utilize the potential of technology. Such an outcome requires improvements in teaching content, approaches, and technology infrastructure to optimize the learning experience. AR can be cumbersome and complicated, which may slow down the process of accessing information. This may be because AR still requires certain hardware, software, or skills, which makes it inconvenient for some students to use. AR's usability also depends on how well it's integrated into lessons and how well the technology infrastructure is developed (see Fig. 1).

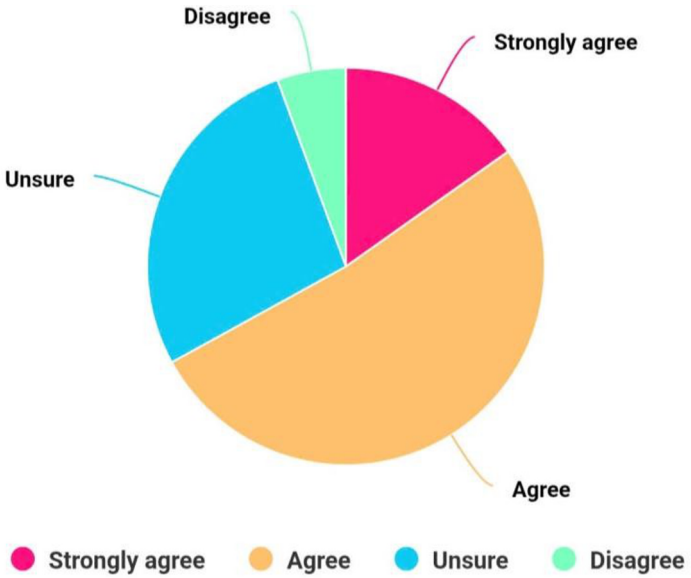


**Fig. 1.** E-learning facilitated the enhancement of students' design skills

## 4.2 The impact of applying AR to virtual classroom

### 4.2.1 Advantages

Augmented reality (AR) is used in graphic design virtual classrooms to improve the learning experience, add a new and captivating element to the learning process, and

help students learn and gain skills effectively. These advantages are clearly shown in the following benefits:

Firstly, AR will bring attractive learning experiences and help create an intriguing and engaging learning environment. Students will engage in more enjoyable and interactive educational activities, thereby enhancing participation and focus in the learning process.

Secondly, AR creates and enhances a natural learning environment by integrating virtual images into the real world, allowing students to visualize their concepts, images, and educational content, which facilitates a deeper comprehension of graphic design concepts. They can see how the design process takes place directly.

Thirdly, AR supports the optimal practice environment and applies theoretical knowledge to virtual reality. It allows educational institutions to customize learning for each student based on their individual abilities and goals. AR can help optimize learning time by providing clear guidance, helping students focus on the most important skills and knowledge, practicing mastery without incurring additional costs, and promoting iterative design activities to perfect the product. Consequently, the graphic design industry values the development of problem-solving skills and creative thinking.

Of the 164 responses, 19.5% of students assessed that these learning environments greatly increased their creativity, and 54.3% said that the impact was quite a lot, accounting for a total of 73.8% of students with positive experiences. The survey results about the impact of e-learning on the creativity and design thinking of digital graphic design students at Greenwich Vietnam. It suggests that the majority of students have positive opinions. However, there are still some students who feel that this environment does not support their creativity well, with 18.9% assessing the impact as little and 7.3% saying that there is no significant impact. This shows that, although e-learning has the potential to help students approach learning methods more flexibly and intuitively, not everyone feels that it clearly supports their creativity. One of the factors that can influence this perception is the way the teaching is delivered. The application of 3D graphics technologies and VR/AR in carefully crafted interactive courses can improve students' immersive learning experiences, promoting innovative thinking. If the educational material is exclusively passive or does not effectively utilize technology, students may exhibit reduced creativity compared to conventional learning methods (see Fig. 2).

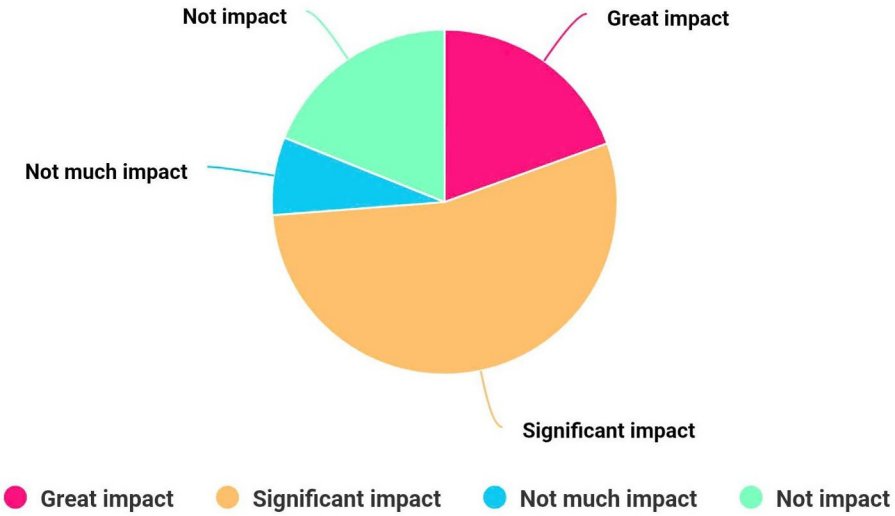


**Fig. 2.** The impact of the E-learning on the creativity and design thinking of graphic design students at Greenwich Vietnam.

The survey results showed positive perceptions of VR/AR in e-learning environments; however, they emphasized the need to improve the quality of teaching and make lessons more realistic and interactive, allowing students to maximize the benefits of these technologies while developing digital graphic design skills. The level of agreement and appreciation for e-learning is at an ideal level. 35.4% of learners said that e-learning with the integration of AR helped them a lot in visualizing concepts and product images (support strongly), and 19.5% said that e-learning helped them to concretize design tasks during the learning process and experience digital graphic design in e-learning environments (support). However, changes are still needed to make the use of technology more effective in the classroom. This process includes enhancing hands-on learning activities, real-world applications, and modern digital design tools to ensure that all students can maximize their creative potential in the new learning environment (e-learning). 6.7% of students encountered significant challenges (no support), while 38.4% had difficulty learning digital graphic design on their own through e-learning and unfamiliar with the new learning method (neutral) (see Fig. 3).

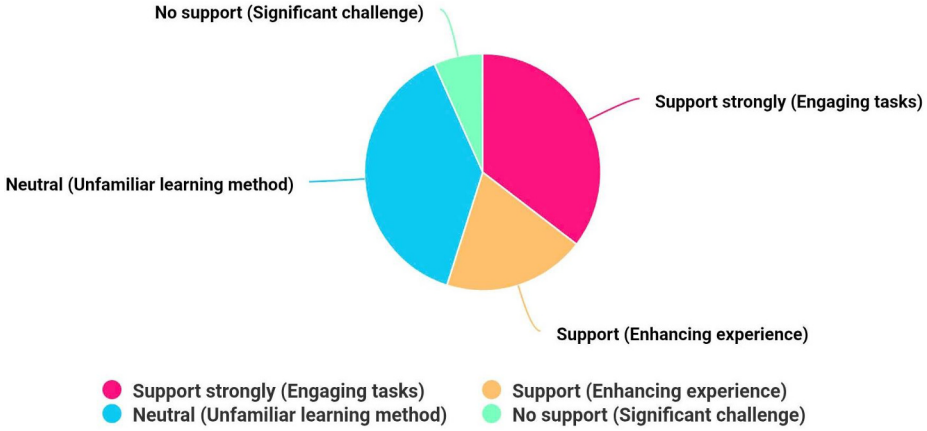


**Fig. 3.** AR supports learners in completing their learning tasks within the E- learning environment.

### 4.2.2 Disadvantages

While using AR in the virtual classroom in the graphic design industry offers numerous benefits, it's also important to consider some disadvantages.

Firstly, it requires a high-tech system. AR requires the support of special technology and equipment. The process can be difficult for students who do not have the right equipment or a slow internet connection. Intergrating AR/VR technology costs a lot at first, which is especially true now that training costs need to go down to make companies more competitive and train more effectively.

Secondly, some students may have difficulty using AR technology. These limitations can create inequality among students. Furthermore, learners are more likely to lose their privacy when they take part in online activities and virtual spaces. AR may require students to provide personal information to participate in activities. This personal information can be exposed and raise privacy concerns.

Thirdly, using AR means making course materials and classroom activities that work together, which is hard to do: creating AR content requires in-depth knowledge of both graphic design and technology. Not all instructors have the ability and knowledge to develop this content. In addition, the application of technology can lead to dependency on it. If the AR or gamification system malfunctions or crashes, it can significantly impact learning. Dependence on technology can create instability in the teaching process.

The survey results show that most students still have some problems when they try to learn graphic design on their own in an online setting. Out of the 164 responses, 6.7% of students said they had many problems, and 38.4% said they had quite many problems. That's a total of 45.1% of students who said learning in a digital environment was a big problem.

Common challenges in implementing AR in e-learning design classrooms may include: Instructors do not provide direct instructional guidance. Many students continue to struggle with self-learning and solving technical problems. Even with access to

online resources and lectures, complex design tools often cause delays in projects. Another reason is limited interactivity. Although e-learning can provide an immersive educational experience, students may deem it ineffective if it lacks real-time interaction and individualized content. Furthermore, self-directed learning abilities are essential. To engage in online learning, students must possess time management skills, critical thinking abilities, and a proactive approach to knowledge acquisition, competencies that not everyone excels in. Last but not least, inadequate technological infrastructure. Certain students may encounter difficulties using e-learning platforms due to inadequate hardware, unstable internet connectivity, or insufficient technological proficiency.

### 4.2.3 Challenges

Developing AR content for lectures requires a high level of expertise in graphic design, as well as knowledge of technology and user experience design. Lecturers must constantly update their knowledge and skills to create engaging learning experiences. Furthermore, to use AR, training institutions may need to invest a lot of money in building e-learning applications, building multimedia content and technical infrastructure. Such costs can be a barrier for educational institutions with limited financial resources; AR requires the support of specialized devices, while gamification requires a strong technology platform. In order for this to work, the technology infrastructure must be strong enough to support the use and implementation of these technologies; To be successful, AR requires active participation from students. If students are not interested or ready to engage in the learning process, the effectiveness of AR tools and e-learning will be reduced; AR content development and deployment can be time-consuming and resource-intensive, but it may not engage learners. This process poses challenges in terms of lesson planning and lesson implementation resources. Therefore, to maintain the appeal and effectiveness of e- learning, AR applications need to be regularly adjusted and updated, as well as invested in how to implement interactivity in the classroom. This process requires continuous commitment and attention to content development. Sometimes, the use of AR can distract learners or fail to promote a deep understanding of the content. They are dominated by technical operations, interactions with AR tools... Such situations can raise questions about the real effectiveness of these tools...

The survey results showed that a significant portion of students experienced some impact when moving to an online learning environment. Out of the 164 responses, 16.5% of students said their motivation had dropped, and 26.8% said it had dropped significantly. 43.3% of students said they had not dropped in motivation, which suggests that they can stay interested and focused while studying online, while 13.4% of students are unsure. The data indicates that there is a group of students who are unable to adapt well to the online learning model and cannot maintain their learning motivation without being too affected by the change in teaching methods. A decrease in learning motivation in e-learning and the metaverse may be caused by the following factors: Direct interaction with teachers and classmates is absent. Hew and Cheung (2014) state that students are more interested in the lecture material when they are learning in person, but e-learning can make learners feel alone and cut off from others. The learning

environment presents challenges. Students may find it difficult to study when they are surrounded by things like social media, entertainment devices, and their home environment (Dwivedi et al., 2021). Students may struggle to gain practical experience in the real world. Students may find it harder to learn, especially in digital graphic design, when they can't go to a physical classroom to try things out, share their ideas, and get immediate feedback (Wong & Siu, 2012) (see Fig. 5).

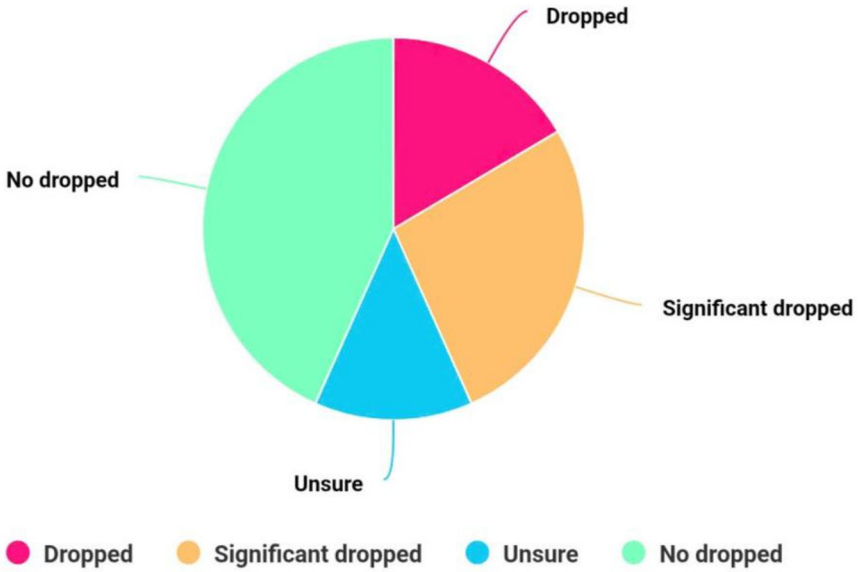


**Fig. 4.** Students' motivation within AR intergrating e-learning.

Most students still do not view it as their primary learning method. There could be several subjective reasons for the reluctance, such as the fact that technology is limited, people can learn on their own, or digital content isn't as appealing as traditional teaching methods. Digital graphic design also needs a lot of interaction and hands-on practice, which may not be possible with traditional e-learning. This also poses challenges to expanding the application of e-learning in teaching. Although AR has the potential to overcome some of the limitations of e-learning by creating a more immersive learning environment, if students are not in the habit of regularly participating in online classes, the transition to e-learning may be difficult. Specific strategies are necessary to encourage more students to access and participate. For example, to improve the learning experience, you could change the learning content, make it more interactive, or use constructivist teaching methods.

### 4.2.4 Opportunities and potential

In contrast of 45.1% of students who said learning in a digital environment was a problem, 48.8% of students said that they encountered only a few difficulties (had only

minor problems), and 6.1% did not encounter any difficulties (had no problems). This data shows that, although e- learning provides flexibility and access to VR/AR technology in teaching graphic design, a large proportion of students still feel that they have not fully adapted or are still hindered in the self- study process. The fact that 33.5% of students were only slightly affected and 16.5% were not affected suggests that motivation can be maintained with appropriate adjustments in teaching methods. E-learning and the metaverse may make it difficult to stay motivated, but if teachers make the right changes and the school backs them up, using this way of learning to teach digital graphic design can be very helpful for students.

The survey at Greenwich Vietnam, conducted across 8 classes, evaluates the teaching and learning performance of students in experience design as follows: A total of 164 students majoring in graphic design (specialization and TopUp stage) participated and expressed interest in the learning method that applies AR in interactive design and user experience; The rate at which students evaluate the quality and attractiveness of AR content applied in the graphic design process: 95%; Students expressed an 86% satisfaction rate with AR application experience designs on websites and the connection of traditional graphic publications to interactive products online; The percentage of digital graphic design students achieving a pass or higher (merit or distinction) in subjects that incorporate AR applications is 80%. The rate of students' ability to apply knowledge and skills from interactive design and user experience courses to graphic design projects (including graduation projects, digital graphic design competitions...): 82%; The rate of traditional graphic design lecturers switching to an interdisciplinary approach, researching the application of information technology in general and AR in particular in teaching digital graphic design: 100%. This positive result shows that AR/VR technology brings an engaging learning experience, helping them grasp knowledge more easily and interestingly; AR allows learners to see and interact with graphic elements and visual designs. Students can see and feel aspects that cannot be seen in traditional learning, helping learners develop a greater grasp on graphic design; AR allows learners to participate in content creation, testing ideas and creativity. The program encourages creative thinking and develops project management skills; AR allows for customization of learning content for each student based on their individual abilities and goals. Students can focus on specific areas that they are interested in or need to develop; AR allows learners to practice and develop practical skills in a virtual environment. They can simulate the design process, test ideas, and learn about graphic design tools and software. In addition, AR can help students develop portfolios, demo products, and even participate in real projects in the field of graphic design, helping them prepare for their future careers. AR is being used to teach subjects related to interactive design and user experience products.

### 4.3 Recommendations of applying AR to virtual classroom

The research includes the student's experience, pedagogical activities, environmental conditions, operational methodologies, and the creative design process. The content encompasses both real and virtual activities within the e-learning environment. There

are activities for teaching and learning, as well as activities for giving students experience. These activities follow the steps or phases of the creative process. Creating a prototype image is a crucial step in the product design process. This process of creating a prototype image goes through many iterations to try, fail, and perfect the final solution before it is accepted and put into production. If done with the right method and process, it will save time and effort and increase efficiency. One way to accelerate the process of making prototype images is to let users see what the prototype product will look like at each stage of development. Reduce errors and time-consuming editing. When real images and augmented reality are used on different levels to make prototype images, it can be easy for users to edit, change, and improve the visual images of the prototype product. With a graphical user interface and interactive principles, users can change and combine different levels of augmented reality images while making prototype images. Prototype images are made from augmented reality layers over the real environment where the product is used or displayed. The graphical user interface lets students edit and interact with prototype images. Details of pre-built components are stored in libraries, along with tips for the best processing at each stage of making the prototype image.

AR-Enhanced Creative Process Framework (AR-ECPF). The proposed model (AR-ECPF) consists of four closely related phases. It reflects the iterative nature of the creative process and the specific ability of AR to enhance each stage. The model is a spiral (inverted tornado). The model's base is the expansion of the AR-supported context, and its top (the climax) is the subject learning outcome. Each step (phase) builds on the previous one to ultimately focus on the subject's target (learning outcomes). Below, we visualize the model and provide a detailed description (see Fig. 5).

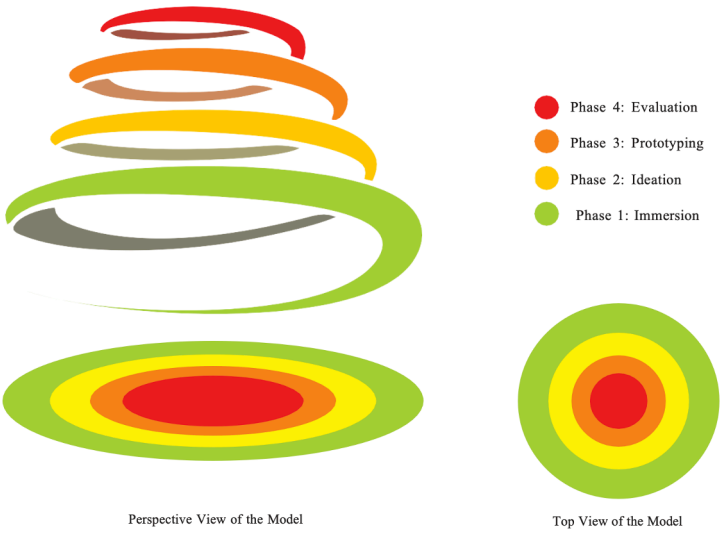


**Fig. 5.** AR-Enhanced Creative Process Framework (AR-ECPF) with four phases: Immersion, Ideation, Prototyping, and Evaluation. Each has corresponding AR-based strategies.

Phase 1: Immersion—This first phase helps learners explore in context. Students explore objects in real-world scenarios and design problems by using AR apps that sync with their location, scan objects, or scan QR codes. By integrating AR-enabled mobile apps and digital sketchpads or any device that supports the use of AR, students engage in virtual tutorials and interact with AR overlays placed over real-world scenarios, such as analyzing signage in a public space, allowing them to explore design problems in authentic environments.

Phase 2: Ideation—With the help of AR, students develop concepts to find creative solutions. AR also supports this process by visualizing and interacting with AR-enhanced layered images that overlay sketches onto the environment from Phase 1. These derivative images— visualizations of concepts—will suggest multiple solutions for students as they brainstorm. Students can create interactive mind maps and idea boards enhanced with AR elements, using tools like AR visualization boards and collaboration platforms that integrate with AR plugins to develop and refine their design concepts.

Phase 3: Prototyping—With the creative solutions students have developed from Phase 2, they develop iterative designs to refine and perfect the prototypes of their graphic products. AR is also a key element in helping students interact with the product visualization components in a semi-realistic environment. As a result, students can rapidly prototype using a drag-and-drop AR interface to experiment and iterate until the product is complete. Tools for this phase include a graphical user interface (GUI) with AR interactions and a 3D asset library, promoting hands-on engagement in the design process.

Phase 4: Evaluation— For learners, this phase allows them to test and refine their designs. For instructors, they can preview student design solutions. They can evaluate student designs in a real-world environment with the help of AR simulations. Discussions with instructors and other students in the group help them select the best solutions from the brainstorming results in Phase 3. An e-learning environment with AR support facilitates interactive activities, creative and design experiences, peer feedback, and evaluation. The result is a more effective way to evaluate and iteratively refine designs and engage students in the learning process.

The AR-ECPF suggests an interactive graphical user interface (GUI) that allows users to interact with AR-based images. Users can layer digital images and manipulate these layers, including swapping elements in the design pattern and simulating interactivity in the visual workspace. The AR-ECPF supports the concept development and prototyping process by using feedback mechanisms embedded in the AR scenarios. It encourages students to experiment without fear of failure and can be refined iteratively. Pedagogically, the AR-ECPF aligns with constructivist learning strategies and visual thinking by promoting immersive, hands-on, and participatory design experiences.

## 5. Conclusion

In summary, the case study in Greenwich, Vietnam, shows that students often consider the application of augmented reality (AR) in virtual classrooms (e-learning) as a

tool to enhance their learning experience as well as engagement. It creates motivation, increases retention of lesson content, and improves student collaboration. Integrating AR features into traditional learning can enhance the interactivity of lessons while also providing a three-dimensional feel for prototypes. This is especially beneficial for fields that require a lot of visual aids and hands-on prototyping, such as graphic design. However, there are also challenges and limitations when applying AR in e-learning. Some students find applying AR in e-learning is complicated and potentially slows down the learning process due to hardware, software, or skill requirements. Furthermore, the transition to online learning has barriers. Students agree that online learning has helped them improve their design skills and creativity. However, some assert that there is a deficiency of resources to support them or that the pedagogical approaches utilized are unproductive.

Furthermore, some others persist in facing challenges in autonomously understanding graphic design in a virtual environment or e-learning. The role of the instructor as a facilitator in the teaching-learning process becomes essential. The potential of augmented reality in transforming graphic design education has introduced novel and engaging learning methods. It allows students to engage with graphic elements and visual design in a way that is not possible in conventional settings. AR facilitates the customization of educational information, promotes creative thinking, and enhances project management abilities. To improve teaching quality, AR must be maximized in the virtual classroom. Lecturers can ensure that students have the necessary tools and support whenever they need it. It is necessary to establish a learning environment that encourages self- learning and minimizes the limitations of online education. If these issues are addressed well, the application of AR in e-learning classrooms will be improved and meet the needs of the digital graphic design industry.

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