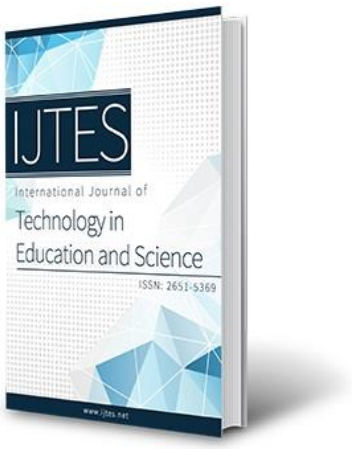

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Enhancing Asynchronous Online Learning with Mobile Augmented Reality Application: A Case Study in Higher Education Business Courses

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Abstract

This case study outlines the development and utilization of a Mobile Augmented Reality (MAR) application to teach an asynchronous online lesson on e-commerce. The MAR technology was leveraged primarily to enhance the presentation of online learning materials, add interactivity to the learning process, and enable students to access the lesson from anywhere via their ubiquitous mobile devices. Two groups, comprising a total of 105 business students, participated in the online lesson during the COVID pandemic. Students' experiences of the implementation were captured through an online survey to find out how the MAR technology was perceived, and what were the benefits and challenges of using the technology. This study contributes to the research on the use of augmented reality in education and offers practical recommendations for teachers to consider when designing and implementing MAR online lessons, including the importance of learner-centered design, careful guidance on technology use, and encouragement of student interaction. The study concludes that augmented reality is a useful tool for improving learning materials and asynchronous online learning practices and MAR applications can be effective for learning with compact materials and micro-credentials.

Introduction

The use of Augmented Reality (AR) in higher education has gained substantial interest in recent years due to its immersive approach to visualizing learning phenomena. A technology that once required a deep technical understanding has now advanced to the point where it is widely employed by educators and numerous previous studies have demonstrated its potential to improve learning (Egresitz, 2022; Moro et al., 2021; Dhar et al., 2021; Kerr & Lawson, 2020; Akçayır et al., 2016; Coimbra, 2015; Bower, 2014; Billinghurst & Duenser, 2012). Augmented reality can provide students with an immersive learning experience, and it has been shown to improve student learning performance (Chen & Tsai, 2012), motivation (Jeffri et al., 2017; Coimbra, 2015; Martín-Gutiérrez et al., 2015; Diegmann, 2015; Billinghurst & Duenser, 2012; Yen et al., 2013; Tarng & Ou, 2012), effectiveness (Zhang et al., 2014; Yen et al., 2013), learning outcomes, (Dhar et al., 2021; Chen, 2020), and 21st-century competencies (Chen, 2020). The use of AR applications in education can also improve students' academic performance (Kaya et al., 2019).

Augmented reality has been widely used in different levels, fields, and subjects of education. It has been used for instance in medical and health education (Uymaz & Uymaz, 2022; McCafferty et al., 2022; Christopoulos, 2022; Moro, 2021; Dhar, 2021), science education (Abdusselam & Kilis, 2021; Arici, 2021; Hsiao et al., 2012), engineering (Egresitz, 2022), robotics education (Chen et al., 2020), design (Kerr & Lawson, 2020), math (Chao & Chang, 2018; Coimbra, 2015), language (Lin & Wang, 2022; Chen, 2020) and history (Lim & Lim, 2020). Augmented reality has been used for several purposes such as to enhance students' laboratory skills (Akçayır et al., 2016), to improve the reading experience, and enhance handwriting instruction (Jeffri et al., 2017; Billinghurst et al., 2001), to facilitate the study of anatomy (Hasibuan & Chairad 2023), to study the life cycle of a butterfly (Tarng & Ou, 2012), to learn the concepts of moon phases (Yen et al., 2013) or to study children's play and storytelling with mirror worlds (Leinonen et al., 2021). Overall, AR is said to be one of the emerging technologies that will have a significant impact on the future of higher education teaching and learning (Educause, 2020).

Because of the COVID-19 pandemic, much of the teaching was done remotely, and the use of online and blended learning models increased dramatically. This has affected that learning technologies have become more vital to higher education and instructors have come to rely on those tools as essential ingredients in their teaching (Educause, 2021). Using recorded video lectures and learning assignments is a traditional and effective way to enhance learning in online and blended learning (Hyttinen & Suhonen, 2022) whereas augmented reality is said to be a novel technology that dramatically shifts the location and timing of education and training (Lee, 2012). Augmented reality can enable interactive and independent learning without the need for teacher assistance (Martín-Gutiérrez et al., 2015), and it adds new dimensions to educational materials improving student-material interaction (Kaya et al., 2019). AR is found to be an excellent tool to address existing issues such as insufficient scaffolding in video learning materials (Chen, 2020), and AR-based learning interaction can act as a catalyst to pique students' interest in becoming active learners in the course (Wang, 2017).

Karelia University of Applied Sciences in Finland offers an eBusiness (4 ECTS) course in the business studies curriculum. The content of the course includes inter alia the basics of e-business and e-commerce. Previously, the course was taught through lectures and exercises, and due to the COVID-19 pandemic, the same lectures and exercises have been implemented online. However, this has not been the most engaging way of learning causing students' participation to decline. As distance learning continued, the purpose was to answer this challenge by creating a mobile augmented reality application to improve the presentation of online learning materials, add interactivity to the learning process, and provide a possibility for students to use their mobile devices to access the learning materials anywhere. While engaging students with a more immersive learning experience the goal was to introduce the use of augmented reality to business students through a hands-on exercise.

This study describes how the MAR application was designed and implemented in an online lesson with two study groups of business students. The application included an AR-enhanced video lecture and learning task for students to practice e-commerce skills. The application was developed utilizing cost-free, open-source software, thereby rendering it feasible for educators to conduct the study irrespective of their technological or financial resources. The objective of this study was to analyze and reflect on the implementation based on students' experiences and the teacher's observations. The findings of this research, along with its recommendations, are anticipated to aid

other educators in the effective incorporation of AR technology in teaching. The more specific research questions were as follows:

RQ 1: How was the use of augmented reality perceived in terms of learning and experience among business students?

RQ 2: What were the main benefits and challenges of using the MAR application in asynchronous online learning?

Background Literature

Augmented Reality

As Virtual Reality (VR) immerses a user fully inside the synthetic environment, augmented reality supplements reality and allows the virtual and real objects to coexist in the same space (Azuma, 1997; Azuma et al., 2001). The augmented reality environment allows the user to see the real world with virtual computer-generated objects superimposed or merged with the real environment (Azuma, 1997; Martín-Gutiérrez et al., 2015). The characteristics of AR are that it 1) combines real and virtual objects in a real environment, 2) it is interactive in real-time, and 3) it is registered in 3D (Azuma, 1997; Azuma et al., 2001). Wu et al. (2013), suggest that AR should be seen as a concept rather than a type of technology, although its realization depends on technology (Diegmann, 2015).

Augmented reality is often described as part of the Reality-Virtuality continuum (Figure 1) where real environments are at the one end and virtual environments are at the opposite end of the continuum (Milgram & Kishino 1994). The process of combining virtual data with real-world data can provide users with access to rich and meaningful content that is contextually relevant and can be easily and immediately acted upon (Billinghurst et al., 2001). The most common example of Augmented reality is the Pokemon Go mobile game where players hunt virtual Pokémon characters visible through their smartphone in a real environment.

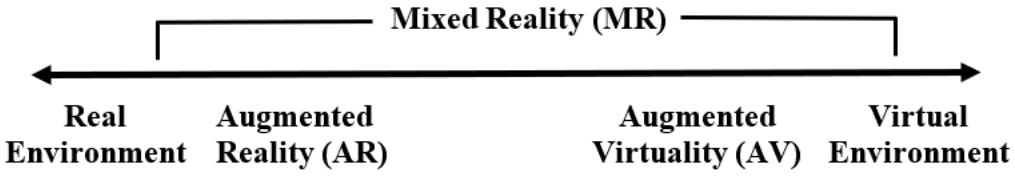

Figure 1. Reality-Virtuality Continuum (Milgram & Kishino, 1994)

Augmented reality experiences can be delivered using different devices such as a headset, glasses, or mobile devices (Educause, 2020). Mobile Augmented Reality (MAR) is a technology that uses ubiquitous mobile devices to view and access augmented reality content (Herpich et al., 2019). According to Chatzopoulos et al. (2017), MAR supplements the real world of a mobile user with computer-generated virtual content. With mobile devices, users can have an AR experience anywhere (Billinghurst & Duenser, 2012). A typical MAR system includes mobile computing platforms, software frameworks, detection and tracking support, display, wireless communication, and data management. The displays for viewing the AR content can be classified into three categories: head-worn displays (HWD), handheld displays, and projective displays (Azuma et al., 2001). AR

glasses are the best option as the projected information is directly superimposed on the physical world (Chatzopoulos et al., 2017), but smartphones are more accessible to all students as more ubiquitous devices (Educause, 2005) and most of today's smartphones are AR-compatible and capable of running AR applications (Egresitz, 2022). The advantages of MAR applications are that they are low-cost technology that allows students to perform independently in certain learning contexts saving the teacher's time spent on repeating explanations (Martín-Gutiérrez et al., 2015). MAR applications allow also the learning materials can be accessed anywhere and anytime with mobile devices (Hanafi et al., 2017).

Augmented Reality and Learning

Augmented reality can be used to empower the pedagogical practices of different learning theories. According to Arievitch (2007, p. 66) the role of information technology in learning "can be conceptualized as supporting students' meaningful learning activities and teacher's efforts to guide their activities in such a way that new knowledge and new mental processes are born in these activities." In constructivism, knowledge is constructed in a meaningful way through active practice (Jonassen et al., 1999), and learning happens when newly acquired information and a learner's previous knowledge are constructed into new knowledge (Lim et al., 2009). Activity theory seeks to explain human cognition (Devane & Squire, 2012) and how an individual uses tools in an activity system and social context to engage in goal-directed behavior (Schmidt and Tawfik, 2022). Students are active learners who acquire new knowledge within meaningful learning activities and teachers should provide suitable learning technologies for students' learning activities (Arievitch, 2007).

Augmented reality provides properly situated scaffolding in the real-world learning context by superimposing rich media objects (Chen, 2020). It adds contextual data to deepen students' understanding and students are more likely to comprehend and remember what they are learning (Educause, 2005). Students can deepen their understanding of interconnected concepts and engage with the content through active engagement (Egresitz, 2022). Yen et al. (2013) discovered in their research in higher education that using augmented reality materials improved students' learning efficiency and increased their motivation and level of concentration. They argued that AR can provide a more intuitive interaction space for students and more authentically deliver abstract concepts. Zhang et al. (2014) used augmented reality to create a mobile digital armillary sphere (MDAS) system and they found that the system significantly improved students' understanding of learning content.

Several studies have found that using augmented reality technologies can improve the learning motivation and performance of students. For instance, Martín-Gutiérrez et al. (2015) used augmented reality in a higher education course on electrical machinery and they discovered that students regard tools as simple and helpful in learning course material. The adoption of new technology increased student motivation, and engineering students could study dangerous devices in a safe environment. Chen et al. (2020) investigate the use of augmented reality in robotics education. They discovered that AR had a considerable positive impact not only on students' motivation but also on teamwork and 21st-century skills. Chen and Tsai (2012) used interactive augmented reality technology to enhance the learning environment of a library. They found that the proposed augmented reality system increased students' library knowledge and significantly improved students' learning performance.

Many studies have also identified the potential of AR technology to improve traditional learning materials that engage students in learning. Chen (2020) used augmented reality videos as scaffolding to improve students' language learning achievements. When compared with traditional video-based learning, AR-based learning improved students' learning motivation, outcomes, and satisfaction with learning. Jeffri and Awang Rambli (2017) created an augmented reality book and mobile application to improve handwriting instruction and AR technology was recognized as a tool to engage students during instruction. Wang (2017) used augmented reality techniques to support a software editing course in a comparative study with college students. Students who studied AR content demonstrated a high level of learning engagement. The study proposed to use AR content as scaffolding to better support blended learning strategies.

The use of AR technologies should always be based on pedagogical objectives, the needs of the educational application, and the target audience (Herpich et al., 2019). The primary purpose of using AR has been to explain a learning topic and provide additional information to students (Bacca et al., 2014). According to Dhar et al. (2021), understanding, practical skills, and social skills are the three main domains of student experiences and learning outcomes that are enhanced by AR technology. Diegman et al. (2015) found in their systematic review that the benefits of augmented reality have been to improve learner motivation, attention, concentration, and satisfaction. AR had also improved collaborative learning, learning curve, and development of spatial abilities and memory, as well as increased student-centered learning, information accessibility, interactivity, and creativity.

A synchronous learning environment promotes social interactions, and live meetings encourage students to be active participants in discussions, fostering meaningful collaboration (Bower, 2015; Park & Bonk, 2007). AR can enable asynchronous online learning and it is said to focus on individual users rather than team activities (Educause, 2005). However, augmented reality can enable new forms of face-to-face and online collaboration, as well as shared learning experiences (Billinghurst & Duenser, 2012). For instance, AR can be used to improve collaborative learning by allowing students to collaborate on learning tasks (Martín-Gutiérrez et al., 2015) or by enabling face-to-face collaboration in a shared physical workspace (Billinghurst & Kato, 2002). Park et al. (2015) discovered AR to be an effective learning technology in their development of a storytelling-based MAR system for collaborative learning.

Students can actively participate in the learning process both inside and outside of the classroom using mobile devices and AR applications (Billinghurst & Duenser, 2012). The ease of use of augmented reality applications has a significant positive impact on students' perceived benefits, which in turn influence their positive attitudes (Kaya et al., 2019). Students enjoy learning with augmented reality devices, which can be used in addition to traditional teaching methods (Moro et al., 2021). For instance, Bacca et al. (2014) pointed out in their research the potential of AR to facilitate meaningful interaction and collaboration while providing an effective tool for students to gain a positive attitude. In addition, Akçayr et al. (2016) used augmented reality technology in higher education and discovered that it significantly improved students' laboratory skills and helped build a positive attitude toward physics laboratories.

Challenges of Using AR

AR projects can vary in technical complexity, reliance on specific hardware, cost to develop and maintain, and other factors, depending on the AR technology being used (Educause, 2005). One reason why teachers are not utilizing augmented reality technologies in their teaching more frequently may be due to a lack of technical expertise in producing AR materials (Bower et al., 2014; Billinghurst et al., 2012). Additionally, students might find it challenging to use AR technologies (Akçayr & Akçayr, 2016), and technical problems like GPS errors may occur while using AR (Dunleavy et al., 2009). According to Bacca et al. (2014), the main challenges of using AR are the difficulties of maintaining superimposed information and paying too much attention to virtual information. Wang (2017) stated that the reasons why students preferred traditional online instruction were a lack of experience with AR applications, a slow internet connection, the capabilities of the student's mobile devices, the size of the screens, and the overloaded information from the AR application.

The often-reported challenge is that students may be cognitively overloaded in AR environments by the amount of new information, using several technologies, and solving complex learning tasks (Wu et al., 2013; Dunleavy et al., 2009). According to Sweller et al. (1998), the intrinsic cognitive load is intrinsic to the information being dealt with and cannot be altered by instructional interventions while extraneous cognitive load can be influenced by choosing the way the information is presented or what learning activities are required of students. Inadequate teaching methods and unnecessary environmental distractions increase cognitive load and too much cognitive load hampers learning (Sweller et al., 2019). The use of new learning technologies and hybrid learning models can also increase the cognitive load on teachers who must master technology while simultaneously teaching online and classroom students (Hyttinen & Hatakka, 2020; Bower, 2015; Cunningham, 2014).

Methodology

A case study research design was applied in this research (Yin, 2017; Cohen et al., 2007) where the MAR application was designed and implemented in a higher education business course. The research was carried out during the spring semester of 2021 at Karelia University of Applied Sciences (Karelia UAS) in Finland. The participants were second-year Business Administration students studying in two groups. The first group (G1) studies in a face-to-face study program, while the second group (G2) in a blended learning program. A total of 105 students (G1: N=63, G2: N=42) participated in the course. Group 1 consisted of students mostly aged 19-24, while Group 2 was made up of adult learners ages mostly over 30. The course studied was a bachelor-level mandatory business (4 ECTS) course, and the MAR online lesson topic was e-commerce. Due to the COVID-19 pandemic, there was a recommendation for distance learning at the time of implementation, and studying was implemented online. Moodle served as the primary Learning Environment (LE), with Microsoft Teams providing online instruction.

The research data was collected through a structured online survey at the end of the online lesson. Webropol 3.0 survey and reporting application was used to create the survey and to collect the data. It was also used to calculate the descriptive statistics presented in Table 1. The questionnaire was pre-tested for functionality and

understanding of the questions. An open link to the questionnaire was placed in Moodle and the program functions prevented the questionnaire from being answered more than once. Students were also reminded to answer the questionnaire. The survey was administered in the student's native language, and the responses were translated into English for inclusion in this paper. The research was carried out following the ethical principles of research (TENK, 2019). Students' dignity and rights were respected during the research. The survey was completely anonymous and the purpose of the study was explained to the students. Responding to the survey was completely voluntary and there were no penalties for not responding.

The survey included eight questions on a 5-point Likert scale (Table 1) and four open-ended questions where students were asked to describe 1) how AR worked for teaching and learning in the course, 2) what were the benefits of using AR in teaching, 3) how the use of AR could be developed, and 4) other comments related to implementation. Student's answers were analyzed using themes and the process included familiarizing the data, selecting research-relevant data, and identifying key themes related to the research questions. The relevant data was then described and interpreted under the themes in relation to the course implementation. The instructor's observations throughout the process were used to interpret the students' experiences and to draw conclusions and recommendations for the study. Students' answers are presented in quotations and referred to by Group (G) and Student (S) (e.g. G1S1 = Group one, first students' answer) in the findings section. The quantitative data were analyzed using descriptive statistics and the results were used to supplement the qualitative data. The questions on the Likert scale were answered by 43 (79%) students from Group 1 (G1) and 33 (68%) students from Group 2 (G2). The number of responses to open questions ranged from 6 to 35 (G1) and 7 to 29 (G2).

The Design of the MAR Online Lesson

The Objectives of the Lesson

The utilization of augmented reality in e-commerce has become increasingly prevalent in the business sector and business students should be familiar with the use of AR technology. Therefore, the objective was to provide students with hands-on AR experience while also meeting the lesson's learning objectives: 1) comprehending the significance of e-commerce in business; 2) understanding the advantages of e-commerce and analyzing an online store's operation (SWOT analysis).

The instructional design of the lesson included that students use their mobile devices to access the MAR application which comprises a video lecture and a learning task. The lecture provided students with concise information on the basics of e-commerce and the learning task involved students performing a SWOT analysis of an online store's operation. Simply, the students were asked to view the lecture and accomplish a learning task. The teacher's role was to demonstrate the use of the AR application, appraise the students' learning tasks, and monitor the usage of AR technology.

Developing the MAR Application

According to previous research, augmented reality is a low-cost technology that can enhance the learning

experiences of students (Martín-Gutiérrez et al., 2015) and AR applications can be developed and implemented using widely available and accessible tools (Hajirasouli et al., 2022). There are numerous AR platforms available, such as ZapWorks, Arilyn, and Blippar. The chosen platform for the development of the MAR application was ZapWorks, which utilizes WebAR technology.

WebAR is an abbreviation for augmented reality accessible through a web browser (Zappar, 2020), and it eliminates the need for separate AR applications to be downloaded and installed. This feature makes the use of AR with students much more convenient. However, WebAR technology requires the use of a trigger image and a QR code to access the web page that launches the AR content. Therefore, the students were instructed on how to read QR codes and where to find a QR code reader application if necessary.

Educators may encounter obstacles in creating augmented reality experiences due to their limited technical expertise (Bower et al., 2014; Billinghurst et al., 2012). To overcome this challenge, the User Interface (UI) and functionalities were created using a web-based platform (ZapWorks designer) that necessitates no advanced programming skills or installations. Before incorporating AR into educational courses, educators should carefully consider several factors, including the amount of information presented on AR applications, the capabilities of students' learning devices, and the design of the learning content (Wang, 2017).

To avoid overwhelming students with excessive information, the user interface was designed to be simple and instructive (Wu et al., 2013). When accessing the AR content, students were presented with a video lecture and two-point instruction floating in their current learning environment (1. Watch the video lecture. 2. Complete this assignment.). Clicking the video image launched the video while clicking the instruction text launched the learning assignment. Furthermore, the functionality was configured so that the learning assignment was launched automatically upon the completion of the lecture video.

The production of the video lecture involved the utilization of MS Teams for recording and Windows video editor for post-production editing. For the learning assignment, a PowerPoint slide was created. Common file formats such as *.mp4 and *.jpg were used to ensure compatibility with students' mobile devices. To maintain brevity and focus on the necessary theoretical background of e-commerce, the video lecture was intentionally kept under 10 minutes. A nearby national park image was selected to serve as the trigger image, while a QR code was automatically generated on the AR platform. The QR code was subsequently affixed to the trigger image using MS Paint. Lastly, the trigger image was embedded into Moodle, providing students with access to the AR application.

Before completing the AR lesson, students were provided with detailed instructions on how to operate the AR technology. These instructions in conjunction with the lesson objectives and submission folder for the learning task were integrated into Moodle. Additionally, the instructions were thoroughly reviewed by the teacher in a collaborative online Teams meeting at the outset of the lesson. Subsequently, students independently engaged in the AR lesson.

Findings

The results of the multiple-choice questions are presented in Table 1. Based on the results there were no significant differences between the groups. In three questions G1 had the more positive responses, while in five questions in group G2. The majority of students felt they had achieved the MAR lesson's learning objectives well while augmented reality was found to be an effective technology in online learning and in conveying the learning task. The majority of students found the AR content to be effective in promoting learning and useful for engaging with the subject, with only four students less convinced. The results clearly show that AR was found to be easy to use and students would like to use AR technologies in their future studies. Only one student (3%) in Group 2 was unwilling to use AR in future studies, resulting in a small difference between the groups.

Table 1. Augmented Reality in Online Learning

Question (Q)	Group	1	2	3	4	5	Count	Average	Mdn
Q1. AR technology worked well	G1	0 %	0 %	16.3%	48.8%	34.9%	43	4.19	4
in online learning	G2	0 %	3 %	6.1%	45.4%	45.5%	33	4.33	4
Q2. AR technology worked well	G1	0 %	0 %	18.6%	39.5%	41.9%	43	4.23	4
in delivering the lecture	G2	0 %	6.1%	12.1%	39.4%	42.4%	33	4.18	4
Q3. AR technology worked well	G1	0 %	2.3%	11.6%	48.9%	37.2%	43	4.21	4
in conveying the learning task	G2	0 %	3 %	15.2%	42.4%	39.4%	33	4.18	4
Q4. I achieved the learning	G1	0 %	2.3%	9.3%	32.6%	55.8%	43	4.42	5
objectives of the lesson	G2	0 %	0 %	3 %	36.4%	60.6%	33	4.58	5
Q5. Content made with AR	G1	0 %	7 %	18.6%	53.5%	20.9%	43	3.88	4
technology promoted my learning	G2	0 %	3 %	33.4%	33.3%	30.3%	33	3.91	4
Q6. AR technology helped in	G1	0 %	2.3%	30.3%	46.5%	20.9%	42	3.86	4
engaging with the topic	G2	0 %	9.4%	25 %	31.2%	34.4%	32	3.91	4
Q7. The use of AR technology	G1	0 %	2.3%	7 %	25.6%	65.1%	43	4.53	5
was easy	G2	0 %	3 %	3 %	39.4%	54.6%	33	4.45	5
Q8. I would like to use AR	G1	0 %	0 %	16.3%	37.2%	46.5%	43	4.30	4
technology also later in my studies	G2	3 %	0 %	12.1%	51.5%	33.4%	33	4.12	4

Note. (1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, 5 = strongly agree)

Students' Experiences

Students' answers to the open questions have been thematized under seven themes and analyzed in relation to the implementation carried out. The themes were: 1) A Versatile Way to Learn, 2) AR Promoted Learning, 3) Increased Engagement and Learning Motivation, 4) A Strong Immersive Experience, 5) Easy to Use, 6) Mobile Learning, and 7) Development Ideas. The responses have been enriched with quantitative data previously presented in Table 1.

Theme 1: A Versatile Way to Learn

AR was found to be effective in enhancing online learning, as evidenced by the high rates of both groups (G1: 83.7%, G2: 90.9%). Students' responses indicated that the use of AR technology added versatility to learning, which was positively received. For example, one student commented, "Nice variation ---> got better excited about the topic" (G1S28), while another noted, "AR technology worked well and it was interesting to see a little variation for regular lectures and assignments." (G1S32).

The introduction of versatile learning experiences can have a positive impact on students' retention of information, as well as increase their interest in the subject matter. Another student commented, "It was a variation compared to other courses and thus the interest in the task did not 'falter'." (G1S3), while another remarked, "Interesting, no teacher has done that, new and inspiring." (G1S17). AR technology is still relatively new and has not been widely adopted for improving learning materials in higher education business studies. Therefore, using AR technology was perceived as a novel and innovative way to teach and diversify traditional lectures and assignments. Although most students were unfamiliar with augmented reality, they were enthusiastic about using it.

> G2S3: This, in my opinion, brought out very well a new kind of implementation that was easy to use, and to diversify the presentations.
> G2S22: For me, everything worked well, and this is a sign of innovative teaching.
> G1S6: The variety of teaching methods/styles is a big plus! :).

Theme 2: AR Promoted Learning

The AR content was perceived as effective in promoting learning by a majority of the students (G1:74.4%, G2:63.6%) and made learning more engaging and interesting while acquiring new knowledge. As one student commented, “It made it more interesting and at the same time you learned something new.” (G2S21). However, despite the novelty and excitement of the technology, it did not add any substantial content to the lecture. As a student in G2 wrote, "AR technology worked well in teaching but did not in itself bring any additional content, etc." (G2S28).

The AR lesson comprised a video lecture and a learning assignment that focused on the topic of eCommerce and included an objective to comprehend AR technology. The students reported a high degree of satisfaction with the attainment of the lesson objectives (G1:88.4%, G2:97%). Augmented reality was also discovered to be an effective technology in conveying the learning task (G1: 86.1%, G2: 81.8%) and the lecture (G1: 81.4%, G2: 81.8%) for students. The technology worked well as part of the teaching process and the lesson effectively demonstrated the functionality of augmented reality. The practical demonstration of AR was regarded as a good practice to address the capabilities of AR technology. Students described this in their responses: “Work well as part of teaching. Demonstrated the functionality and use of AR effectively.” (G1S31), “The biggest plus was learning something new, as I didn't know about this AR technology before.” (G1S11), “Implemented practically, it opened up the possibilities of AR technology in a completely different way.” (G2S23). AR also aided the learning of e-commerce

theory and was found suitable for studying this subject.

> G2S10: --Also supports the topic and content of the course when AR is added !!
> G1S10: AR technology worked well, especially in the teaching of this course, as AR technology fit well with the topic of the course.
> G2S24: Easy to use and otherwise a good addition when dealing with this topic. By this, I mean that you were able to do and experiment yourself, which I think is a good thing for learning--.

The utilization of AR technology by students revealed it to be a learner-centered tool that is suitable for collaborative learning. Notably, students perceived AR as an effective tool to support learning. For instance, students with dyslexia can find it beneficial to have information in video form that can be viewed repeatedly. As one student stated, “--learner orientation, learning by doing, collaborative working, motivating and helpful for the learner: helps to immerse in and supports, for example, people with dyslexia.” (G1S13). Furthermore, the incorporation of the QR code in the AR lesson provided practical proximity to the lecture, and its use allowed for student engagement. As one student described it, "A change from traditional lectures. Engaging the student through the use of QR code" (G1S10). The learner-centered feel was reinforced by the fact that students were given the autonomy to perform the AR lesson independently at their own pace within a one-week timeline. It is worth noting that some students may experience apprehension toward unfamiliar technology. Thus, precise instructions, both written and oral, from teachers may help mitigate this initial hesitancy. As one student expressed, "I've never used technology like this myself, and in the last lesson when it was mentioned, I was scared that it would be awkward and I wouldn't understand it. The technology was more interesting and fun than just listening to a lecture in collaboration." (G1S17).

Theme 3: Increased Engagement and Learning Motivation

According to the study, the use of AR technology was effective in engaging students with the topic, with 67.4% of students in Group 1 and 65.6% of students in Group 2 reporting positive experiences. This innovative method of study was found to be motivational, with comments such as "It was an interesting, new, clear way to study and very motivating." (G2S6) and "the teaching situation was different, and therefore the motivation to listen was different.--" (G2S26).

The recorded video lecture included the teacher being physically visible in a virtual classroom that served as the background, and subtitles were added with keywords related to the lecture that changed as the video progressed. Students found this approach helpful in focusing on the lesson, as one remarked, "It was nice to watch the video and I focused on it in a very different way when I saw both the teacher and the keywords. Too often recorded lectures are just slideshows spoken. Human faces help focus :)" (G2S16). Another commented, "It was nice to see a physical person in the video, and not just listen to the speech." (G1S16). By incorporating AR technology into the lesson, students were more engaged and attentive than when simply reading text or watching videos. One student commented, "AR technology brought additional interest in teaching and was followed with greater interest than a boring text" (G2S12).

Theme 4: A Strong Immersive Experience

AR technology was experienced to be capable of connecting various digital screens with the real world, thereby providing an opportunity for individuals to become familiarized with a digital learning environment and learning materials. As one student stated, AR technology can "connect different screens to the real world (laptop, mobile phone, tablet, data glasses), a way to get acquainted with the digital environment--" (G1S13). Moreover, augmented reality can offer a more immersive approach to delivering video lectures, rendering them more engaging and lifelike. The incorporation of AR technology in educational settings allows for the easy inclusion of relevant information into lessons and enables personalized presentations.

> G2S11: The pre-recorded lecture included more of a live lecture feel and was more meaningful to follow than just the speech and slide show.
> G2S10: More comfortable following the lecture with AR technology than, for example, as a recording by Collaborate.
> G1S8: Lectures and videos are easy to incorporate and it's easy to give a personalized presentation while keeping the overall message clear.

The integration of AR technology into the learning process facilitated a greater sense of teacher presence, as it brought the teacher to the student's own learning space. In comparison to normal video lecture recordings, AR lectures were deemed more comprehensive, as affirmed by the positive feedback from students such as G2S1's comment that "it was nice to see the teacher 'live' for a long time," and G2S26's observation that "AR technology worked well and brought the teacher into the living room to give a lecture in a completely different way than when using Collaborate."

Traditionally, lectures have been delivered through online recordings or teacher-led lectures. However, with the aid of AR technology, video lectures, and learning assignments can be presented more impressively, eliciting greater interest and engagement from students. A student in group 1 expressed that AR-enhanced video lectures provide "--quite a nice variation compared to the normal online lecture model," (G1S19) while another student reported that it was a "fun and different approach" that increases motivation to complete tasks (G1S16).

According to a student in group 2, it was "much more interesting to watch such lectures than, for example, recorded Collaborate recordings," (G2S9) while another student highlighted the novelty of the learning environment and the potential of AR technology to revolutionize teaching methods. “Different learning environment (not always just online lectures, which are sometimes boring), innovative, nice to see the speaker's face and body language, a good way to illustrate what AR technology is.” (G1S34). Students also recognize AR technology as a future tool for visualizing learning materials, as it offers numerous teaching opportunities and is user-friendly, efficient, and effective in conveying information. As expressed by G1S13, "AR technology offers plenty of teaching opportunities: for both teachers and students. It’s a good practice, easy to use, clear, quickly manageable, and a visualization method of the future."

Theme 5: Easy to Use

AR was found to be easy to use by 90.7% of G1 students and 94% of G2 students. The user interface of the AR application was created to be as simple as possible and the utilization of WebAR technology in delivering the online lesson obviated the need to install separate AR applications enhancing the accessibility. Notably, all students were familiar with scanning QR codes, as it had been previously practiced during the course. The functionality and the ease to use were also evident in the student's responses as "simplicity, clarity" (G1S1), "surprised by the functionality and ease of use" (G2S15), and "everything worked flawlessly and was easy to use" (G2S1).

Theme 6: Mobile Learning

The utilization of mobile phones is ubiquitous among students in their daily routines, and participating in a lesson with their mobile devices increased their sense of practicality with AR technology. Several students noted the importance of AR technology being operable on mobile devices: “Really interesting, easy to use technology. Brand new to me! Convenient when you can follow the lecture on the phone --” (G2S4), “It was done with the phone, so it was appropriate.” (G1S25). The incorporation of MAR learning materials enabled students to engage with the content at any time and location at their own pace. This afforded students greater flexibility in planning their study schedules, as the delivery of instruction was not limited to a specific time.

> G1S30: Variety, learned to use new ways to deliver lectures, got to do it at your own pace.
> G2S4: Snappiness, clarity, easy to follow, for example when traveling by train, without having to carry around a big, heavy laptop. The linking was convenient and the lecture worked flawlessly. :).

MAR technology is particularly effective for improving short lecture videos. As one student described "it worked well, and it certainly works with such short lectures/videos. Because the QR code was read by the phone's camera, the content was also viewed from the phone. In longer lectures, I think this would be impractical but worked in short content like this." (G2S17). This sentiment was echoed by other students who commented on the practicality of shorter videos, as longer videos are more cumbersome to view on a mobile device. The lecture videos in question were highly succinct, with a length of fewer than 10 minutes. The students appreciated the concise delivery of essential subject matter, as exemplified by responses such as "I also liked the compact and appropriate length of the lecture. It presented compactly all the essentials on the subject. More of these! :)" (G2S4), "The video was clear and concise" (G2S1), and "The lecture was short and concise enough to be watched on the phone screen" (G2S25).

Theme 7: Development Ideas

Regarding the development ideas, it was generally felt that the AR performed satisfactorily and did not require any particular enhancements. As one student remarked, “I think AR technology worked flawlessly and there were no areas for development.” (G1S16). Conversely, there exists potential for augmented reality to be employed

more broadly in educational settings and students expressed their interest in utilizing AR technologies in their future studies (G1: 83.7%, G2: 84.9%). This was stated by students as “AR technology could be more widely used in education.” (G1S8) and “--I see no reason why AR technology couldn't be used more.” (G1S1).

The majority of issues reported by students were related to technical difficulties. For example, one student was unable to use the technology on a tablet but found it to work well on a mobile phone. Additionally, the small size of the phone screen was noted as a limitation when viewing lectures, and some students questioned the possibility of enlarging the video. One student felt that watching the lecture on a computer screen would have been easier. Despite the availability of functionalities for video control and enlarging the video within the AR application, some students may not have noticed these video tools.

> G2S7: -- I didn't manage to use the technology on my tablet, but it worked well on my phone.
> G2S5: The screen on the phone is very small when viewing the lecture.
> G1S3: The image is a bit small when viewed on the phone screen, so the size of the text should be increased.
> G2S6: Is it possible to enlarge the image/video without moving the phone closer?
> G2S18: It is easier to follow a lecture traditionally, for example on a computer screen.

According to student experiences, the quality of the image was deemed suboptimal. As one student noted, "maybe the image quality could have been better, but I don't know if you can influence that" (G1S5). Similarly, another student remarked that the "picture quality [was] not the best possible" (G2S10). The video lecture in question had been captured with a computer camera and was recorded at 720p (1280x720), 30 fps. Additionally, one student experienced difficulty reading the text of the learning tasks on a mobile device (G2S19).

Furthermore, a student encountered issues reading the QR code with the initially installed reader but was able to rectify the situation by downloading another application (G1S24). It was also suggested that there should be a possibility to make notes at the same time as the lecture on another tab of the screen (G1S26). The instructional activity was designed as an independent exercise for each student, but there is potential to enhance the lesson interaction through student collaboration. An improvement that was suggested involved increasing the level of interaction (G1S20), but it was not clear from the response whether it meant the interaction between students or between students and the AR material.

> G1S24: In my case, the QR code didn't work at first and I had to download another app to make it work.
> G1S26: --it would be good for the task if you could make notes on a different tab as well.
> G1S20: Improving interaction.

Discussion

RQ1: AR in Terms of Learning and Experience

The use of AR technology should always have a pedagogical purpose (Herpich et al., 2019). In this study the

MAR technology allowed the learning materials and assignments to be combined into a single, simple-to-use application. AR provided an immersive way to present learning materials as well as the opportunity to add functionality and interactivity to the implementation of online lessons. Although it can be difficult to design an immersive and engaging online education setting (Zuo et al., 2022), this study shows that the MAR application can be used in asynchronous learning to organize independent remote learning in an engaging way for students. MAR technology activated remote students during their learning process and students could access the learning materials easily by using their mobile devices. In particular, AR technology was found as a new and innovative way to organize online lessons that can increase students' learning motivation. The immersive experience was evident in the fact that the teaching was perceived as more personal and students felt the teacher was more present in their learning pace.

This study also confirms that AR technology can be used to engage students and increase their motivation to learn (Jeffri et al., 2017; Coimbra, 2015; Martín-Gutiérrez et al., 2015). AR video-based lessons enhanced students' satisfaction compared with conventional video-based learning (Chen, 2020) and AR encouraged students to become more involved with the learning content (Coimbra et al., 2015). Students preferred the AR video lecture over traditional online lectures and video recordings and a genuine interest in AR technology was also reflected in the students' wish to continue using AR in other courses.

A Smart Learning Environment (SLE) is effective and engaging (Cheung et al., 2021; Spector, 2014), and facilitates personalized learning (Hwang & Fu, 2020). In this study, the MAR application acted as an effective mediator of learning and a stimulating new learning environment for students. Although immersion in AR was a good motivator for students, the learning was also contextualized in the students' familiar learning environment making the learning more personalized. This can improve students' learning experience and have a positive impact on their learning outcomes. Students excelled at meeting the learning objectives of the lessons, as evidenced by the instructor's approval of the submitted learning assignments. The hands-on AR exercise promoted students' self-learning skills and allowed them to learn by doing (Akçayr & Akçayr, 2016). The implementation also increased students' practical skills in utilizing MAR technology and it was portrayed as a learner-centered tool. Overall, the use of augmented reality was experienced very positively and students expressed that they had learned to use future technologies.

RQ2: The Benefits and Challenges of Using AR

The design of the MAR application was overall successful. The application did not contain overloaded information or used several technical devices (Wu et al., 2013). The students did not report higher increased intrinsic or extraneous cognitive load in their answers (Sweller et al., 1998). The application was designed to be simple and the lecture concise, covering only the essentials for learning that can be easily internalized. Students were given also detailed instructions on how to use the application. In contrast to what many other studies claim (Akçayr & Akçayr, 2016), AR was found easy to use. AR may not be used in the classroom because the teacher lacks the necessary technical skills (Bower et al., 2014; Billinghurst et al., 2012). In this case, rather than creating an AR application, the majority of the time was spent on creating the instructional video and practicing performing on it.

MAR application allowed students to perform in learning contexts independently (Martín-Gutiérrez et al., 2015) and the teacher's time was saved on reviewing learning assignments and providing learning support to those who needed it. Augmented reality also transported the lessons to the learners and made the content more accessible (Educause, 2005) as the AR learning materials were accessible anywhere and anytime with mobile devices (Hanafi et al., 2017). This allowed students to plan their studying timetables better. The use of mobile devices was viewed as both beneficial and detrimental. As studied previously, the capabilities of the student's mobile devices and the size of the screens may cause challenges (Wang, 2017). AR was discovered to be appropriate for concise content, such as a short video. Smartphone screens were deemed insufficient for longer videos.

The main challenges of the implementation were related to technical issues caused by the variety of students' mobile devices. Some devices may be more powerful and compatible with AR technology than others. The applications used to read QR codes may experience functionality and compatibility issues. Some students may have poor data connections, causing the video lecture to stutter and low-resolution screens to result in poor image quality. Many of these technical issues will be resolved as technology and mobile devices advance. The usability problems can be mostly solved by adding the necessary functionality to the application, such as the possibility to make notes during the lecture.

AR technology can be exploited at a low cost (Martín-Gutíerrez et al., 2015). In this study, no costs were incurred as free software was used. The issue was that the selected AR platform was freely available only for a month, limiting its use for the future. It has been found that AR can promote more interaction among students and between students and the learning material (Akçayır & Akçayır, 2016). The interaction between students and the material was intensive and students felt they learned well from the concise AR material. The interaction among students remained low which is a result of the fact that the lessons were designed to be studied independently and remotely. As a pedagogical development, allowing the students to perform the lesson in collaboration and adding the option for discussion during the lesson could improve the possibility of students' interaction. The main benefits and challenges of the MAR online lessons are summarized in Table 2.

Table 2. The Main Benefits and Challenges

Benefits	**Challenges**
• Students' activation through emerging technology. • Increased interest, concentration, and motivation. • Learner-oriented and learning by doing. • A more impressive learning experience. • Mobile learning, completing the lesson anywhere and anytime. • Improved student-material interaction. • A concise learning material. • Easy to use and low costs. • Learning new technology for future use.	• Technical problems such as problems reading the QR code. • Poor image quality. • A small phone screen for viewing a lecture • No possibility to make notes during the lecture. • Interaction between students during the lesson. • The validity of the free software.

Conclusion

This study shows that MAR holds the potential to enhance students' asynchronous online learning experiences and traditional learning materials adding interactivity and variety to learning. AR-enhanced learning materials can activate and motivate students to learn. However, the successful implementation of MAR applications requires careful pedagogical planning and application usability. To effectively incorporate MAR, teachers must ensure that the learning content and application design are learner-centered, concise, and clear, with careful guidance on the use of technology. Teachers should plan for potential technical difficulties and provide clear instructions and support to students. In addition, teachers should encourage interaction between students during the lessons, monitor student learning, and use high-quality software to ensure the validity and reliability of the technology. In this study the application was designed and implemented using cost-free, open-source software, which enables any instructor to conduct this study irrespective of available funding, addressing the lack of studio-level equipment such as high-quality video cameras, green screens, professional AR and video editing software, or skills to use them. Although the use of professional equipment and technical support would have further enhanced the AR lesson experience.

AR has a lot to offer in terms of diversifying learning materials, increasing student-material interaction, and providing meaningful learning experiences. While AR does not increase the content of the studying material, it provides an immersive and engaging way to present it, thereby increasing students' interest in the subject matter. The use of MAR technology was perceived as an effective way to enhance learning and increase student engagement compared to traditional methods such as reading text or watching videos. Based on the teacher's observation student activity during the lesson was increased in comparison to previous online lectures. The joint kick-off session was attended by nearly all students, who also displayed enthusiasm to work independently on the AR lesson. There were no significant differences in the opinions of the groups, implying that the group of students or the age of the students in the groups did not appear to play a significant role in this study. Although it is obvious that not every student prefers a particular learning method or technology. Based on the findings, we can conclude that MAR applications are useful for studying concise learning materials and micro-credentials, whereas a mobile phone may be perceived as too small and inconvenient for longer periods of study. Incorporating AR into higher education business studies can also prepare students to utilize this technology in their future careers.

Recommendations

This study explored the potential of using MAR technology as a pedagogical tool in higher education, particularly in the context of business courses. The findings provided insights into how MAR can improve students' learning and learning experiences, as well as the benefits and challenges of implementation. In this section, we offer practical recommendations for teachers who are thinking about using MAR in their classes:

1. *Pay attention to the learner-centered application design:* Carefully design the MAR application and the learning content to be easy and simple to use for students. Consider the pedagogical and technical aspects of the design. Learning content such as videos should be concise, as they are viewed on mobile

devices. When building the MAR application, use valid and reliable software to ensure that the application will work properly in future lessons.

2. *Provide clear instructions and guidance for students:* Even if the MAR technology is easy to use it is essential to instruct students before using the application. Some students may not be familiar with the technology and may need encouragement to use it. Therefore, give students clear instructions on how to use the application and explain how the application works. Also explain why the technology is used, so that students understand the purpose of the technology. Be prepared to provide support during the lesson and plan for potential technical issues such as difficulty in reading QR codes.
3. *Encourage interaction during and after the lesson:* The MAR application may be learner-oriented and offer learning by doing experience, while the interaction between students during the lesson may be low. Therefore, encourage interaction between students and allow students to collaborate in the lesson. Provide also a possibility for discussion and reflection during and after the lesson.

Limitations and Future Research

The study employed a case study research design to investigate the students' experiences of implementing the MAR application in an eBusiness course. While the validity of the study may be limited due to the lack of a control group, two lessons were implemented using the same design to improve the research's reliability. The survey provided valuable information about students' views on the use of the MAR application. The study was conducted in a specific course at one university, which may limit the generalizability of the findings. The researcher's involvement in the study, as well as the clear and precise description of the research process, has an impact on the study's validity, allowing the extent to which the findings are generalizable to other cases to be determined (Cohen et al., 2007). Although this research provides useful insights into the benefits and challenges of implementing MAR in a business course, further research with larger samples and different courses and educational settings is needed.

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