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Application of Augmented Reality in Architectural Education*

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Augmented Reality (AR) has found many purposes over the years, and it is constantly being explored and improved. With its effective and attractive combination of virtual objects superimposed in a real surrounding, many have considered or already implemented AR technology as a part of developing education and learning process. With architecture being a visual and engineering discipline, this paper questions how beneficial would presenting and learning through AR be for architecture students. Two AR files have been created and tested by students, and then a survey has been carried out. The first file includes an exhibition space that questions the potential of a presentational tool in education, while the second file includes a green roof cross section questioning its usefulness as an education manual developing students' engineering and visual comprehension. The aim of this paper is to present the results in order to enhance the current architectural education system through AR, having in mind the benefits of a more pragmatic, interactive tool, as well as the disadvantages and limitations that come with it. It is concluded that the students praised the green roof file more, finding that they lack better understanding of engineering concepts, rather than needing AR as potential presentation tool. Possible outcomes could be an app-textbook or an online textbook containing different educational AR files helping students master subjects and prepare them for the exams.

Keywords: augmented reality; architectural education; presentation; learning process; iOS device

1. Introduction

Technologies containing Virtual Reality (VR), Augmented Reality (AR) and their many variations have been experimented on and tested for decades now. While VR immerses the user completely in a synthetic, parallel world consisting of virtual objects in a virtual environment, AR might be a better, more humane solution. Azuma concludes that 'AR allows users to see the real world, with virtual objects superimposed upon or composited with the real world [. . .] AR technology creates a blend between the real world and the digital, bringing the digital 3D objects literally in our hands [. . .] this experience can be educational, social and entertaining.' [1]. AR could represent an upgraded version of a hologram, meaning that a virtual object is being investigated in a real setting, therefore it means having a world within a world. However, AR is not limited to certain technologies and it represents a larger category with three representative definitions: (1) AR is a blend between real and virtual objects in a real environment; (2) objects are interactive in real time; (3) AR allows aligning real and virtual objects (e.g., 3D objects) with each other [1].

What is most crucial for its extensive use and accessibility is the fact that 'we do not consider AR to be restricted to a particular type of display technologies such as head-mounted display (HMD)' [1], meaning that more available gadgets can carry out the role of a medium – our smartphones, in fact. 'The inbuilt camera perceives live feed from the environment and sends it to the image capturing module where it separates the live feed into frames and one that frame is sent to the image processing module.' [2]. AR has also become a major study focus in recent years and popular research field since it no longer needs costly hardware and advanced machinery such as head mounted screens [3, 4], which allows many creative, affordable implementations that can be popularized and widely used.

Another liberating and favorable fact about AR is that it is not limited to the sense of sight solely. 'AR can potentially apply to all senses, augmenting smell, touch and hearing as well. AR can also be used to augment or substitute users' missing senses by sensory substitution, such as augmenting the sight of blind users or users with poor vision by the use of audio cues, or augmenting hearing for deaf users.' [5]. With these comprehensive definitions, the use, purpose, and aims of AR are broadly extensive.

2. Theoretical Framework

In 1997, Ronald Azuma wrote the first survey on AR providing a widely acknowledged definition of

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AR by identifying it as combining real and virtual environment while being both registered in 3D and interactive in real time [6]. The first outdoor mobile AR game, ARQuake, was developed by Bruce Thomas in 2000 and demonstrated during the International Symposium on Wearable Computers. In 2005, the Horizon Report predicted that AR technologies would emerge more fully within the next 4–5 years; and, as to confirm that prediction, camera systems that can analyze physical environments in real time and relate positions between objects and environment were developed the same year [7]. This type of camera system has become the basis to integrate virtual objects with reality in AR systems. In the following years, more and more AR applications are developed especially with mobile applications. Mobile applications use a MAR to visualize wireless sensor node data by overlaying the measurements on camera images [8]. The orientation of the camera is detected with the help of markers. An analysis of the delay and client-side processing required for server-side processing of camera images has been made [9]. They show that the latency caused by the combination of local processing, network latency, and server-side processing is under one second and should still provide a good user experience. Marker tracking is a heavy operation [10]. Unlike VR technology and its requirements, a great advantage and one of the most significant factors for the widespread use of AR technology is that it no longer needs costly hardware and advanced machinery such as head mounted screens [4].

In the commercial sector, technologies that exploit AR would be beneficial to more easily sell a specific product or to help the user during the purchase through the use of applications that allow viewing in 3D with the use of a camera; in this way, the chosen product could be seen in real time with different colors or any accessories before purchase [11]. This technology does not just improve the user experience. It also provides a great business opportunity for service providers and, therefore, for companies. The development of smartphones, sensors, high-end camera quality, tracking technology, and wireless networks allowed the implementation of AR applications even in mobile environments [12]. Breakthrough technologies such as virtual and augmented technologies are increasingly significant driving forces for engaging today's tech-savvy Gen Z consumers [13]. Specifically, different types of augmented reality (AR, hereafter) applications accessible via QR codes, smart devices, large interactive screens or through projectors have been widely adopted for advertising and marketing purposes [14]. These AR applications embed digital content such as product information, virtual images, and animations into the real physical environment for user interface via intermediary devices interactively in real time [15]. Examples of commonly adopted AR systems enable consumers to interact with virtual make-up or clothing try-on sessions, in addition to enjoying a virtual tour in a museum, hotel, opera house, and more. AR has been in commercial use for years now with some campaigns by Gucci including 'try on shoes' iOS application that further explores remote online shopping, or interior design planning with the KARE interactive system that brings 3D furniture objects to your home. This helps the customer in visualization, decision making process and improves profitability. Also, AR found its purpose in medical and military training, as an affordable and accessible simulation exercise. However, it must be noted that when dealing with such delicate and serious matters, AR technology should not represent the main training tool, but an additional output.

In the tourism sector, IoT applications combined with AR could be used to provide various services relating to the status of flights and baggage, or for assistance during travel within an unknown city, through the use of applications that allow viewing interactive maps, buses, and metro lines, or allow travelers to automatically book a taxi based on their preferred location and preferences [16]. Nowadays, there are several fields in which these technologies are already taking hold. For example, AR is used in museums for guided tours or in general IoT applications used in private homes and smart cities [17, 18]. In the past modern technologies were used only by cultural heritage professionals, such as archaeologists, architects and civil engineers. Recently, more and more museums, archaeological places and exhibitions have begun to explore the use of new technologies to create new types of interaction with the aim to enhance the user experience [19]. Preservation, education, and entertainment are essential points regarding cultural heritage sites, and technology integration is viewed as an essential element of service delivery in a museum environment [20]. AR technologies have been presented in the heritage sites many times, from guided tours, to using smartphones as a 'lens' to see different historical layers of a site or destroyed parts that are reconstructed through AR. In museums it has also been paired with Natural Interaction in order to 'touch', grab, move and rotate certain objects that are not on display because of their fragile state.

When it comes to the AR use in architecture, building and engineering, the idea is that Augmented Reality applications can provide a more accurate view of what will be built, including all layers of materials, engineering structures and details, as well as installations that are often too complex to understand through drawings. For this, 3D plans and even virtual model holograms are used to improve the understanding of the project and facilitate the execution of projects. And even during construction, the ability to see through walls and understand the path of the technical installations facilitates the process, reduces the possibility of errors, and even [21].

In the educational environment, AR technologies can help students understand some technical, structural, or engineering concepts better. For instance, through the use of simple smartphones equipped with AR applications, the entire structure of the human body or the molecular structure of a chemical agent, or even the structure of the solar system can be viewed in 3D [11]. Nowadays, teachers are increasingly challenged to be creative in novel practice; therefore, teacher education, based on design thinking, is important [22]. Technology and engineering teachers nowadays have to avoid the simple transfer of knowledge of materials, mastery of special technical skills and techniques, and correct use of instruments [23]. As already mentioned, and concluded by Azuma [15], one of the main characteristics of AR is that it is offering a service in real time, and in a real setting. Its use is a contextual one, and processing information this way has many layers to it. In 2020, in the middle of the SARS-CoV-2 outbreak, with most universities worldwide closed and resorting to e-learning methods, too many professors are reluctant to finding and applying innovative assessment methods, different from the traditional written examinations, which generates additional stress and helps to point out the need for evolving engineering education again and continuously [24].

It can be concluded that:

- AR can minimize the misconceptions that arise due to the inability of students to visualize concepts such as chemical bonds, because AR allows detailed visualization.
- AR also has the advantage of allowing macro or micro visualization of objects and concepts that cannot be seen with the naked eye
- AR displays objects and concepts in different ways and at different viewing angles which helps the students to better understand the subjects [2].

The educational component of developing technologies can be even further explored with virtual internship models given the involvement of all parties of interest in terms of internship: students, colleges or faculties (teachers) and companies (mentors) [25]. This means that AR could play an important role in students' extracurricular activities (like summer internships), but also serve as a stepping stone into the business world and different job opportunities after they have finished formal education.

In the era of fast developments and changes, we became consumers of rapid, lapidary content that does not require having a long and devoted attention span. In that light, available technologies need to be tested for the purpose of new educational models that are more suitable for today's students. Having in mind that the real world is three dimensional and dynamic, active and ever-changing, AR in education can represent an adequate interactive and amusing learning medium that provides a level of realism and captures attention.

3. Methods

Having in mind that AR is already a present medium in galleries as a part of exhibition concepts, as well as it is widely used for studying technical details and engineering structures, it is adequate to hypothesize that AR technologies could become a perfect tool for architecture students. With architecture being a visual discipline that combines both engineering and innovative way of thinking, as well as requires skills design-wise, the students could potentially understand some technical concepts better, as well as be more immersed in their design process. Using a design-based research approach similar to Multimedia Development Life Cycle (Fig. 3), we designed an instructional media in six stages: concept, design, material collecting, assembly, testing and distribution, and evaluation. This became the survey layout.

Namely, we developed files offering options and experience similar to the KARE furniture retail system. First, the user would need their iPhone or iPad, since the files are iOS compatible only. Second, the user accesses two different AR files through a link – first one being of an exhibition containing posters and pictures (Fig. 2), and second file being a technical detail of a green roof cross section model (Fig. 1). The principle is similar to the KARE experience: first the user needs to rotate the phone around the room in order to scan and map it. When the space itself is loaded, the user chooses between two options of viewing the file – AR mode or object mode. AR mode viewing includes the virtual object superimposed onto the environment (the room) the user previously scanned, while the object mode excludes the real setting and shows the virtual model only, without the background (white backdrop). With two fingers the user moves and rotates the item (the virtual 3D object), as well as adjusts its scale. Instructions are given on the screen explaining how to scan the room and it is also possible to take a picture (a print screen), which

Fig. 1. The green roof file in object mode.

Fig. 2. The exhibition file in AR mode.

later can be shared via e-mail, messaging or social media. We hypothesized that the students generally found the use of new technologies very beneficial, bearing in mind it could be used with their personal phones and without any significant knowledge in the field of computer programming.

3.1 Participants

This study involved a survey administered to students during the 2021/22 school year at Bachelor studies level (the classes of the course Architectural Technologies) and Master academic study program of Architecture at the Faculty of Technical Sciences, University of Novi Sad, as well as students from the preparatory program for the enrolment to the academic studies of Architecture, and PhD students. The research population is chosen with an aim to have a different background and knowledge level, but at the same time to be working on specific topics where the use of AR could be recognized as a tool for developing their expertise in the field. Students were from above mentioned courses, chosen intentionally regarding their knowledge level and course curricula.

3.2 Survey

The survey was administered in both semesters of the 2021/22 school year, and all students were provided with a link to approach the AR application and files prepared by the authors of the research. The instructions for the use were given by the teaching assistants and students were guided how to use it. All students were able to see both AR files, the first one being of an exhibition space that questions potential use of AR as a presentational tool in education, and the second AR file being a technical cross section of a green roof which tests whether AR benefits the understanding of engineering concepts better.

Both files could be viewed in AR mode or object mode, which is another point of comparison in the survey. There was an option to take a picture (a print screen) of the scene, which later can be shared via e-mail, messaging or social media. Afterwards, the survey concerning the use of AR application was administered electronically, consisting of 27

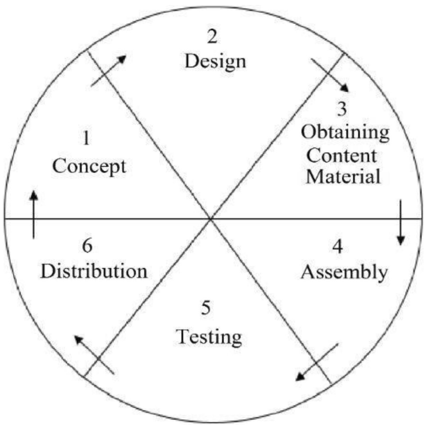

Fig. 3. Multimedia Development Life Cycle.

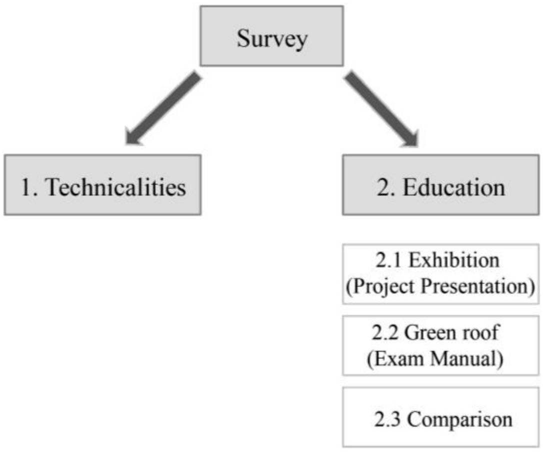

Fig. 4. The survey structure.

questions: 9 technical questions, 7 regarding exhibition file, 8 regarding green roof file, 2 comparison questions and one final question where students had a chance to fill in any suggestions, comments, or express any difficulties experienced while using the AR files they tested.

The survey conclusions have been based on a sample of 125 completed surveys (N = 125), which is the same number of students that tested out both AR files altogether. The questions were organized in two larger sets: (1) the first set being general questions about students' year of studies, GPA etc. (technicalities); (2) while the second set of questions refers to education purpose of the AR files themselves, (2.1) about the exhibition file (project presentation and design help), (2.2) about the green roof file (better engineering comprehension, exam manual), and finally, (2.3) comparative questions.

4. Results

As already mentioned, two iOS compatible AR files have been developed and shown to the architecture students at the Faculty of Technical Sciences, University of Novi Sad. Altogether, 125 students participated in the survey. The first file (exhibition) had the purpose of questioning whether it has potential presentational quality in education, while the second file (green roof cross section) questioned whether it can offer better engineering and technical knowledge and exam preparation use as an exam manual. The aim is to compare if there is a greater need and usefulness in using AR when presenting projects to the professors/future clients, or in better understanding constructions and engineering concepts while learning.

Both files could be viewed in AR mode or object mode (which is one of the most crucial comparisons in the paper). The questions regarding the students' need to take a print screen and share it with their peers (via e-mail, messaging or social media) have also been covered in the survey, representing an important factor of whether they find the files interesting and worth sharing or not. As previously mentioned, the survey has been divided into different sets of questions: Technical Questions, The Exhibition File Questions, The Green Roof File Questions, and Comparison Questions (Fig. 4).

4.1 Technical Questions

Students from different years of study have been testing the files and answered the survey: second year (30.4%), third year (16.8%) and fourth year (24%) of undergraduate studies, as well as students enrolled in the master studies (16%). Preparatory enrollment courses students (8.8%) have also been included, as well as advanced university students (1.6%), and PhD studies (2.4%). There were 35 (28%) male students and 90 (72%) female students.

The students' general GPA (grade point average) is 8.74, while the average grade in the software related subjects was 9.38, and the average grade in the architectural design and interior related subjects was 9.23.

The majority of the students (55.2%) has never used AR technology on their smartphones before. The first setback was that 16% of the students did not own any iOS operating product and hence had to test the files on someone else's gadgets (iPhones or iPads). They pointed out that in order to reach equality in availability, better said accessibility; android versions of the files would have to be developed as well. They graded AR technology (both files) at 8.19 as being easy and comfortable to use.

4.2 The Exhibition File Questions

The students graded the experience of using the AR exhibition file at 8.5 in general. When it comes to comparing the AR experience to the experience of a real exhibition in a gallery setting, taking into account the challenging pandemic restrictions

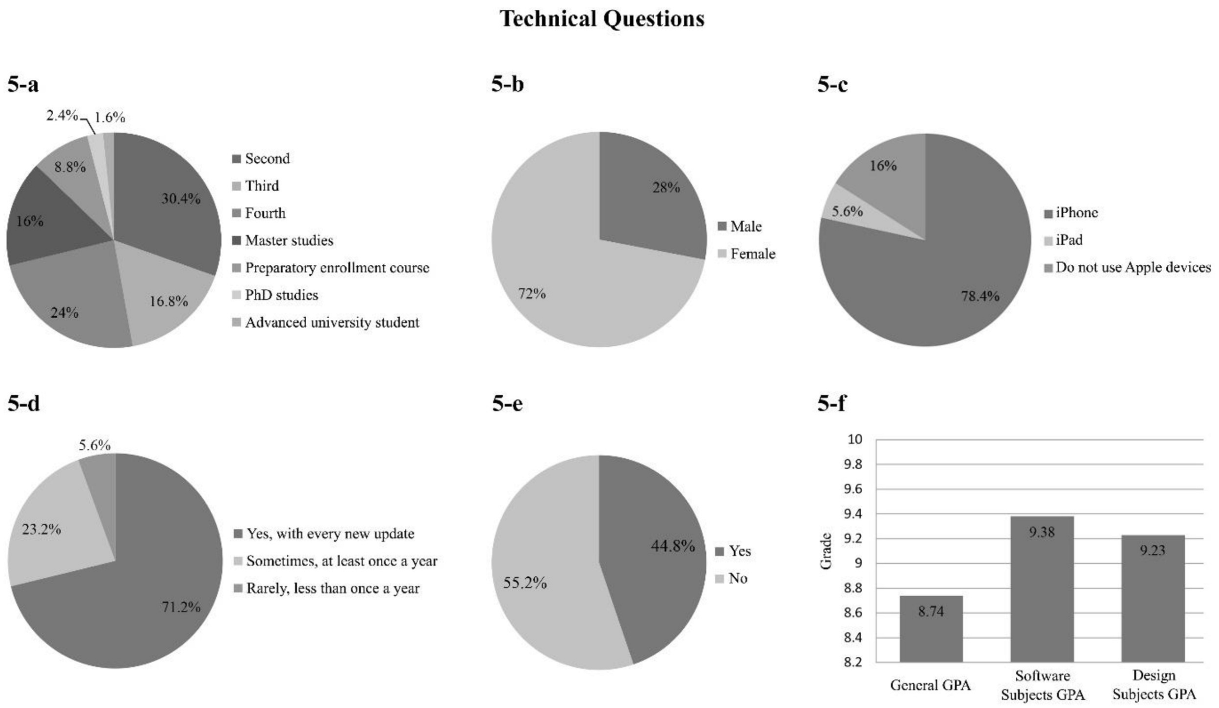

Fig. 5. Technical Questions: (5-a) Year of studies, (5-b) Gender, (5-c) What type of iOS device do you use? (5-d) Do you update your software frequently? (5-e) Have you ever used AR technology on your smartphone before? (5-f) GPA.

(reduced working hours of galleries and museums), students mostly said that it is still more convenient to visit galleries during opening hours 57 (45.6%). Next in line was the answer that they liked both AR and visiting galleries equally 56 (44.8%). The answer 'using AR is more convenient' 9 (7.2%) had insignificant percentage, and some even answered with 'I do not like any' 3 (2.4%).

When it comes to the need of taking a photo (print screen) of some AR exhibition position in their private interior (workroom, living room), the students answered that they felt the need and did it 39 (31.2%); not for now, but will do it 64 (51.2%), while 22 (17.6%) said they have not felt the need to do it. In case they have taken or would take a photo, 57 (45.6%) have sent it to a friend or promoted it through social media, while 50 (40%) would eventually do it, but have not yet. 11 (8.8%) do not want to promote the photo they had made, and 7 (5.6%) had not taken a photo and would not promote it. When the question of whether they would share the exhibition file with their friends through SMS, Viber or e-mail was mentioned, the majority said they would 78 (62.4%), some said that they have not yet, but would do it 38 (30.4%), and some said they would not 9 (7.2%).

When it was asked whether they needed a sound explanation of the picture they saw in AR (for example, as the voice of a curator), the majority said 'may be, but it is not necessary' 88 (70.4%), some said 'yes, for sure' 24 (19.2%), and finally, 'no, there is no need for that' was answered by 13 students (10.4%). Finally, regarding whether the students found the display in AR or Object mode more informative, mainly the answer was 'the same' 63 (50.4%), followed by 'AR mode' 44 (35.2%), and in the end, 'object mode' 18 (14.4%).

4.3 The Green Roof File Questions

The students graded the experience of using the AR green roof file at 8.54 in general, stating that it is very easy and comfortable to use. When it comes to comparing this experience with the experience of studying engineering details and constructions from the traditional literature (print or web page with 2D and 3D drawings), the most common answer was 'it is easier for me to see the detail through AR' 62 (49.6%), followed by 'I like AR and literature equally' 42 (33.6%), and 'I need both to complement each other' 13 (10.4%). Not many have said that it is still easier for them to master details with the help of literature 7 (5.6%), and only one student (0.8%) said that it is equally difficult for them with both the AR and literature.

When it comes to the need of taking a photo (print screen) of AR green roof in their private interior (workroom, living room) to use it as a reminder later, the students answered that they had made a photo 58 (46.4%), have not thought of it, but sounds interesting 50 (40%), and then finally, 'no' 17 (13.6%). In case they have taken or would take a photo, 58 (46.4%) would send it to a

Fig. 6. The exhibition file viewed in AR mode through iPad.

Fig. 7. The exhibition file viewed in AR mode through iPhone.

friend, 39 (31.2%) have not yet, but will do it eventually. Fifteen (12%) said they have not taken a photo, while 13 (10.4%) have not taken a photo and would not want to promote it. And if they would share the AR green roof file with their friends through SMS, Viber, e-mail, 71 (56.8%) said they would, 34 (27.2%) said they have not yet, but will do it, and 20 (16%) said they would not.

When it was asked whether they needed a sound explanation of the green roof they saw in AR (as the voiceover of the professor or assistant professor), 82 (65.6%) concluded that maybe, but it is not necessary, 25 (20%) said yes, for sure, while 18 (14.4%) concluded that the object with instructions itself is enough. The usefulness of AR technology for mastering the curriculum regarding building structures and engineering details (load-bearing structures such as pillars, beams, walls or roof constructions, installations, engineering layers) received a very high grade of 8.9 out of 10.

Finally, regarding whether the students found the display in AR or object mode more informative when it comes to the green roof, mainly the answer was 'the same' 67 (53.6%), followed by 'AR mode' 36 (28.8%), and in the end, 'object mode' 22 (17.6%).

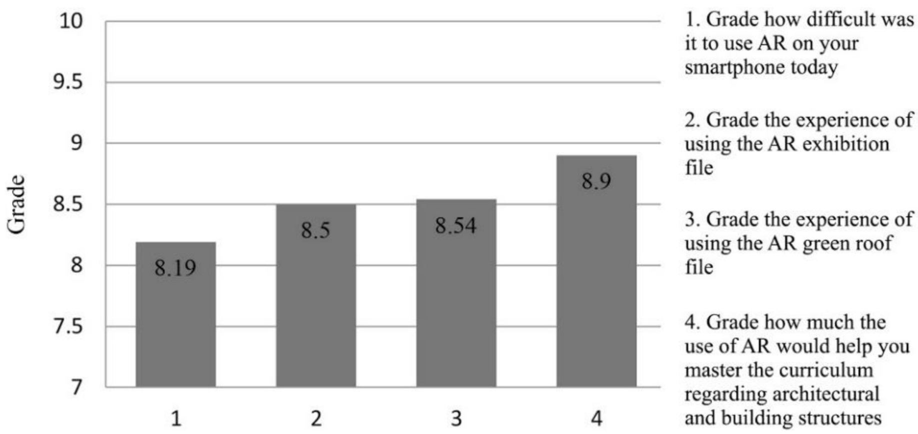

Fig. 8. AR technology grades, survey results.

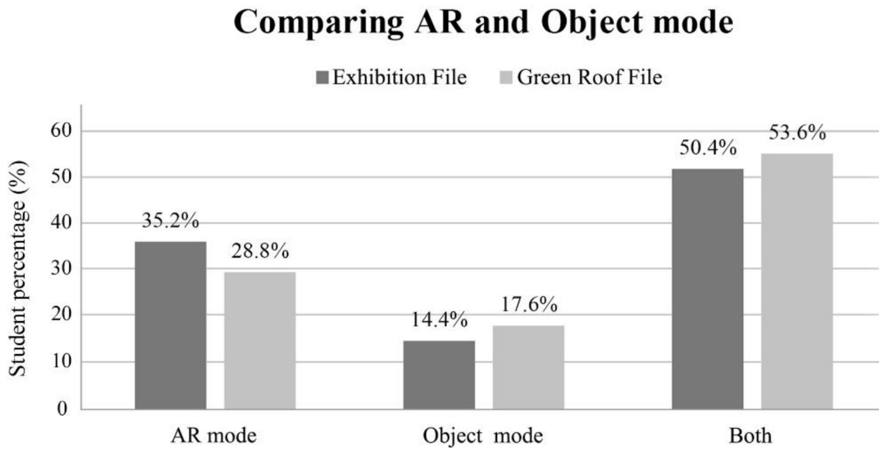

Fig. 9. Comparison between AR and Object mode regarding their usefulness to the learning process showing both files compared.

Fig. 10. The green roof file viewed in AR mode through iPad.

Fig. 11. The green roof file viewed in AR mode through iPhone.

4.4 Comparison Questions

When it comes to comparing the two files, students mostly found both files very useful (56%), but if we would analyze the files separately, the students stated that they had found the green roof (34.4%) more relevant and useful for their learning process than the exhibition file (8%). A few (1.6%) said that neither file is useful for their learning process.

Regarding whether the files would be useful for presenting their projects (for example, to the professors or potential investors), 58.4% said that both files are useful, 24% said the green roof is more useful, 15.2% said the exhibition is more useful, and 2.4% said that neither file is useful.

5. Discussion

We can conclude that a few opposing pairs of questions and topics were found within the survey. First, we have two totally different AR files, the exhibition representing a design file, potentially more used as a presentation tool, while the green roof file represents a technical section, potentially helpful to visualize engineering concepts while learning. Basically, two purposes are confronted:

'AR presentation in education' *versus* 'AR learning in education', and we can now draw conclusions that the green roof got more positive feedback from the students. Since architecture is a visual domain that requires mastering engineering subjects (mechanics, statics, structures, construction details, materials, architectural technology), it is presumable that the approach to the teaching and learning about engineering concepts could be accelerated through the use of AR. This would improve the educational process and beam it easier, more contemporary and innovative, especially for the incoming Gen Z students.

Another constant comparison in the survey would be between AR mode and object mode, with AR mode being more informative to the students and receiving more praise. There is also a comparison between iPhone and iPad use experience (Figs. 6, 7, 10, 11), with students better experiencing the files through iPad since it has a larger screen, and better resolution quality. In this double-natured way, two main sets of advantages and disadvantages were recognized among the answers: (1) technical advantages and disadvantages of AR files and (2) applicability and purpose – advantages and disadvantages of AR files.

5.1 Technical Characteristics – Advantages and Disadvantages of AR Files

A definite advantage of AR use in education is the fact that many already have smartphones that could carry out the role of an AR provider, so no other gadgets are necessary in the process. First of all, 68.8% of the students did not disclose any difficulties and confirmed that the system was functional and easy to operate. However, 31.2% responded that they had certain difficulties and challenges, most commonly the disadvantage of not having an iPhone or iPad (not having an iOS device). Another common answer was the difficulty when positioning/rotating the object in space, inadequate perspective, non-HQ background definition (the backdrop becoming blurry when inserting the 3D object in AR mode), which all probably represent issues with the file itself. Some students mentioned that they had difficulties with the file loading (slow loading and bad internet connection), which could potentially be poor internet connection, or the lack of support by the device. This might have to do with an inadequate iOS update as well, since 28.8% of students do not update their software frequently. Other answers include: difficulty of using the file on a small screen, difficulty of having an inadequate space (small rooms filled with furniture), difficulty following the file without a sound explanation, and difficulty following the green roof layers without text. Even though the green roof file did in fact have text and bullets naming the layers shown, we must assume that some students did not know how to access this text, which leads us to the AR disadvantages explained in the next section.

5.2 Applicability and Purpose – Advantages and Disadvantages of AR Files

AR files could potentially become a wide spread, universal way of studying, available to anyone and reinforcing globalization. A back-up educational model and an alternative solution has to be readied for any potential future crisis, such as the SARS-CoV-2 outbreak was. Analyzing the recent years' experience, it is certain that all types of 'hybrid' education methods have their advantages (for example, the use of Zoom or MS Teams platforms in teaching has significantly developed multitasking, efficiency and improved the teacher-student communication). AR could allow remote studying, an overall better understanding and viewing of the object, while making the learning process more amusing. However, general disadvantages mentioned in the survey include not having enough information and knowledge about AR from the start. Schools and universities must broaden their curriculum in order to explain to the students both benefits and drawbacks of technologies such as these. Even though the technology is developing at a rapid rate, somehow it is still not explained and implemented enough in the education system. Students must be taught about the technical principles and usage of the AR as well, so that they know how to optimize all of its options and resources. A few students even doubted the sole purpose of AR, concluding that it is unnecessary, difficult to comprehend, and has no actual contribution. Another doubt was being cast about the disadvantage regarding personalizing experience, meaning that AR is generic and lacks the social component. Remote learning can isolate students and leaves no room for discussion and debate.

However, AR has the potential to become more interactive and this includes methods such as touch based, gesture based, and voice-based interactions. With the implementation of Natural Interaction (NI) combined with AR, the options could be further examined: students could potentially hold, rotate and move objects. Implementing Handheld Displays or Pinch Gloves for more realistic and haptic experience could perfect the learning process, as well as offer social interaction possibilities since students could see and experience the same as the person wearing the primary HMD (Head-mounted display). Similar experiment has been carried out in the Mediterranean Science Festival, in Limassol, Cyprus, as part of a showroom of The Cyprus Institute [26]. The professor or assistant professor could hold the main device presenting and showing objects/lessons to the students, all while interacting and discussing the topics with students. To conclude, AR has great potential for mass use, especially when combining it with other systems, however, for now it is elusive to which extent any additional equipment would be needed and if so, could it become widespread.

6. Conclusion

In the presented research, a little more than a half of students have never used AR technology before and it can be concluded that its use is quite intuitive. However, the AR education system has to be perfected in every way possible: applications should be available for both iOS and android users, and also, the system must be more optimized for different internet speeds. The quality of the system itself could be optimized and more developed as well (no blurriness, introducing voiceovers, combining AR with Natural Interaction, allowing students to communicate and share thoughts with one another and professors/teaching assistants using many AR advantages in terms of social interaction and users physically being in the same room). Drawing conclusions from the survey, students are in need of AR technologies helping them understand some technical, engineering concepts better (architectural and engineering details, construction, materials, statics), having in mind that they embraced the green roof file better. AR has a great potential and can be used both independently or as an invaluable complementary manual. Potential outcome of this research could be an app-textbook or an online textbook containing educational AR engineering structures and details helping students master curriculum. On the other hand, the AR use output in project presentation might be a more optional path for students to embark on, suggesting that AR use should not be forced upon in every architectural education field and should be reassessed for certain groups of subjects. This research represents a step ahead when it comes to a more interactive way of teaching and learning, and although it currently faces significant technological shortcomings, it can propose much needed dynamic components in the teaching process, as well as represent another type of insight into specific research topics.

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