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Article

A synergistic teaching approach in interior architecture education: Plumbing system learning with augmented reality

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ABSTRACT

This study explores an innovative teaching methodology in interior design education incorporating Augmented Reality (AR) technology to create an immersive and interactive learning experience for building systems learning. AR transforms traditional didactic teaching into dynamic, 3D visualization, allowing students to explore and interact with technical/mechanical systems within the building in real-time. This approach also bridges the gap between theoretical knowledge and practical application, offering a deeper understanding of the intricacies of plumbing applications and their impact on interiors. In this context, interior architecture students taking the Environmental Systems Building Dynamic (ESBD) course were given a different practical experience in which AR technology has adapted through the drawing applications given in the course. It was observed that the students experienced the practice of plumbing knowledge through a digital and 3D practice compared to the classical method, and the effects of this experience process on the students' course and interior architecture practice were questioned through a survey. Considering the findings obtained, increasing students' theoretical knowledge of ESBD courses and their 3D practices have been evaluated through classroom-based experiments. Its impact on student engagement, comprehension, and problem-solving skills is questioned, shedding light on how AR technology could revolutionize the teaching of ESBD. Based on the student's experiences, suggestions are presented that this approach can be integrated into interior architecture education in different courses and can also be a guide in professional projects in the sector.

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INTRODUCTION

The traditional teachings of environmental building systems in interior architecture education have historically relied on conventional didactic methods and theoretical teaching. Although these approaches are fundamental, they may need to meet the current needs of the time and provide students with a comprehensive and practical understanding of which plumbing is an integral part of sustainable interior architecture.

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This study addresses this gap by presenting an innovative pedagogical approach that utilizes the power of Augmented Reality (AR) technology. It has the potential to revolutionize the teaching of environmental building systems by providing students with dynamic, interactive, and immersive experiences in water plumbing. This approach bridges the gap between theory and practice, transforming the learning process into an engaging and multidimensional journey that allows students to explore, interact, and understand building systems in real time.

LITERATURE REVIEW

Building Systems in Interior Architecture Education

The course on Building (Service) Systems in Interior Architecture Education is a critical component within interior design departments worldwide. It provides students with a comprehensive understanding of the technical and mechanical aspects that underpin the creation of functional and sustainable interior spaces. To prepare students for the complexity of real-world design difficulties, this course aims to close the gap between theoretical understanding and practical application.

The curriculum is structured to align with industry standards and emerging trends, ensuring graduates are well-equipped for the dynamic field of interior design.

Building Systems courses in architecture and design education generally have essential topics such as historical evolution, environmental considerations, systems, installations, technology, regulatory compliance, practical applications, and professional practices. Under all these main topics, it is explicitly focused on building physics, mechanical, technical, electrical and acoustical systems, and sanitary systems such as water plumbing, heating, ventilation, air conditioning, cooling, lighting, electricity, fire, energy saving, architectural acoustics, etc (Echols & Ding, 1971; Binggeli, 2003; Oral, 2015; Sevinç et al., 2015).

Some accreditation bodies stated the course content of building physics courses in interior architecture education. The Council for Interior Design Accreditation (CIDA), a significant authority in interior architecture education, has a “Standard 14: Environmental Systems and Human Wellbeing” at CIDA Professional Standards 2024. According to this standard, interior architects practice the principles of acoustics, thermal comfort, indoor air quality, plumbing systems, and waste management regarding environmental impact and human well-being (CIDA, 2024). Moreover, The Interior Architecture/Design Education Policy (IFI) states the biases of interior design education in its policy; the environment topic is explained as "consideration for significant environmental factors, including sustainable development and the impact of climate change” at the standard of Interior Architecture/Design graduate's qualities (IFI, 2020). The Interior Design Educators Council (IDEC), a collaborative council, defines the core values of interior design education in the organization's mission. It claims that ethics form the basis of interior design education, which also covers social, cultural, environmental, and international themes (IDEC, 2021).

Interior design students can effectively understand these systems if they consider building physics, components, construction, and interior details. Thus, practical applications become more important for this course. Also, interior designers should know building systems to complete the interior finishing and design details in professional life.

Yüksel scrutinized the courses on physical environment control for interior architecture education in Turkish Universities in his 2018 study. The course plans for the Interior Architecture Departments were examined in research conducted within the scope of 28 universities. The contents of these universities’ mandatory courses, Environment, Physical Environmental Control, and Building Physics were investigated in terms of semesters, credits, and topics (Yüksel, 2018). A study on the environmental approaches that can be taught to students in interior architecture education is presented, and methods with suggestions on how and in what way environmental approaches can be included in undergraduate interior architecture education. In this context, the study also includes methods and suggestions developed for effectively using water under the components of building physics in interior architecture education and design processes (Adıgüzel Özbek, 2015).

Yılmaz and Eren examined student perspectives on digital and traditional drawing methods in environmental design studios of the landscape architecture department and the influence of these methods on academic performance in the course. Initially, a variance analysis was performed to identify if there was a disparity in student attitudes toward traditional and digital drawing techniques in the environmental design studio. The digital and traditional drawing techniques students acquired in the environmental design studio correlated with their academic accomplishments, and the difference between the groups was noteworthy (Eren & Yılmaz, 2022).

There has also been an investigation into how real-world design experiences and a problem-based learning methodology were applied to create educational materials in three-dimensional multi-user virtual environments (3D MUVEs). To help those who want to create these 3D MUVEs and use these environments for teaching, a design model was proposed. Students in the third year of the Department of Computer and Instructional Technology Education at a public university in Türkiye make up the study group (Doğan & Tüzün, 2022). In Iraq, a study investigated the degree to which the prerequisites and directives of environmental education sanctioned by the National Architectural Accrediting Board (NAAB) are fulfilled in the academic curricula of the Architecture Department of Al-Nahrain University. The outcomes indicated that to comply with the NAAB stipulations on environmental education, there is a necessity to initiate applied practical facets of academic projects and the establishment of auxiliary laboratories for implementing the software and computations on such projects to validate the projects' performance from an environmental standpoint (Wahhab & Rizko, 2019). Some researchers examined the significance of Building Service Systems (BSS), especially how they should be contemplated during the initial architectural design stages. Course projects are utilized to underscore the importance of 3D digital modeling in revealing potential clashes and conflicts between BSS, specifically the plumbing systems on one side and between the design and those systems on the other. Additionally, a survey was conducted among students (Abdelhameed & Saputra, 2020).

Using AR Technology in Interior Architecture Education

The key feature that makes Augmented Reality (AR) suitable for architectural education is its ability to understand and transform information between the virtual and real world. AR can serve as a technical instrument within an architect's workspace. It allows viewing three dimensional (3D) drawings of a planned building, created with computer-aided design (CAD) programs, through a device with an AR mobile application (app). This provides the designer and user with a more realistic experience about various details, such as the facade appearance of the building, the materials to be used, and design feedback (Diao & Shih, 2019; Wang et al., 2013). Moreover, the architectural curriculum is directly linked to the real world, and it is critical to establish stronger connections with industry. AR could directly produce drawings of existing structures and virtual images of buildings on the construction site. AR accelerates the architectural work process and assists in the design phase and verification of the building (Balakrishna, 2013).

AR applications enable students to engage with a world of reality outside of the confines of traditional classroom instruction (Chen et al., 2011; Diao & Shih, 2019; Kamarainen et al., 2013). Besides, integrating digital technologies into educational processes is considered one of the difficulties encountered between students and teachers. However, students show great interest in these technologies. In educational institutions, there is an ongoing insistence on maintaining traditional strategies due to the fear of disrupting the field content due to the complexity of some computer applications. (Wang et al., 2013) Additionally, some studies have reported that the impact of AR technology on learning yields efficient results (Hsiao et al., 2010).

Another study highlighted the use of AR in architecture and construction education. AR technologies have proven beneficial in these fields in this study, but this app in higher education teaching and learning environments is still being explored (Hajirasouli & Banihashemi, 2022). A smartphone AR app that supports interior design educational activities was provided by another researcher. Students were able to learn about interior layout design and the implications of various design layout choices thanks to the program. Using their mobile devices, users were able to interact with 3D representations of virtual objects that were placed on top of a design layout plan (Chang et al., 2020). This article is another relevant research that discusses the role of AR in architecture education. The study includes the increased use of technology in education, particularly the rise of augmented reality. It focuses on how AR-based experiences are created and implemented in didactic activities within undergraduate architecture and urbanism courses. Also, it presents bibliometric analysis and quality assessment to highlight the benefits and challenges associated with incorporating AR in teaching AU, hightlighting various approaches to its development and application. (Skubs & Cuperschmid, 2023).

These studies suggest that AR can enhance interior architecture education by providing a more interactive and immersive experience. However, more research is needed to fully understand AR's potential in this field and develop effective teaching methods that incorporate this technology.

METHODOLOGY

The case study was performed in Türkiye, with the Department of Interior Architecture and Environmental Design student participants in İstanbul Medipol University. During the Environmental Systems Building Dynamic (ESBD) course, students were given a plumbing practice in two different formats. Conventional and digital methods were questioned based on students 'aspects and experiments. The case study was practiced in two stages. The first step is to create a framework and offer a quantitative benchmark based on research as a point of comparison for how easily interior architecture students can use instructional technologies (Vlachogianni & Tselios, 2022). Then, the attitudes of interior design students towards conventional and AR tools in ESBD courses were scrutinized. In the second stage, it is argued that a new system usability evaluation has an approach to contribute to this course and design education and development of the technological systems that are used in educational settings, and the impacts of AR tools over understanding plumbing systems were analyzed in System Usability Scale (SUS).

Research Questions

Very few studies in the literature of in-class applications for building physics and building systems are given in interior architecture education, explaining these applications through traditional and digital methods and measuring the differences between these several methods. Thus, the research is aimed to identify students' perspectives regarding the 3D modeling interface usability and the dominant aspect of plumbing drawing/design that they would use as future interior designers under three essential questions;

Q1. What are the attitudes of interior architecture students toward traditional and digital drawing tools provided in ESBD training?

Q2. How do the AR apps affect academic and sectoral success in ESBD courses?

Q3. Is there a relationship between the department's age, language, and level of education and the AR apps and convectional drawing method?

The course of ESBD

This compulsory course is provided in two semesters at the department. In the first semester, environmental, physical, environmental control, the evolution of building systems, city networks/distribution, sanitary systems, sewage systems, and heating systems were taught. The second semester includes HVAC, lighting, electrical, fire security, fire emergency, sprinkler system, and sound/ architectural acoustics (Syllabus of ESBD, 2024). Drawing-based applications are more common in plumbing because the plumbing needs to be solved in detail at the intersection of interior finishing decisions and building structure. Thus, plumbing is a more critical system for interior students to understand building components and wet area design. In this course, students perform conventional drawing practices over AutoCAD-based plans. Two different programs just applied the case studies at their official course hours. In this course, some goals have been expected from students under the education outputs at the end of the year. These students learn installation solutions, relationships between buildings and installations, relationships between interior and wet area design, and 3D perception of building components and interior details.

Instruments

Three instruments were used in this research. The first gathers information about environmental systems, building systems, education processes, and drawing methods.

The second one is to develop a survey for a questionnaire using the Attitude Scale and System Usability Scale (SUS) with likert and open-ended questions. Attitude scales are used to understand students' perceptions and preferences towards different drawing techniques, design approaches or educational methods. This scale is a tool including both positive and negative statements with five response options for respondents, from strongly agree to disagree strongly (Eren & Yılmaz, 2022). Also, Tarakci Eren et al. (2018) showed that these questions are reliable with Cronbach's Alpha test in their study. The SUS scale is used to evaluate the usability of design software or other technology-based tools. It quantifies and evaluates the usability of the digital interface for users. The SUS consists of ten statements under negative and positive attitudes. It consists of a ten-item questionnaire with five response options for respondents, from strongly agree to disagree strongly (Yong et al., 2020; Kandil et al., 2021; Vlachogianni & Tselios, 2022; Huang et al., 2023). However, its application in architecture/ design education does not seem to be a standard research topic. Eren & Yılmaz (2022), Tarakci Eren et al. (2018), and Yong et al. (2020) developed survey questions incorporating the SUS scale and the attitude scale to assess design students' perceptions regarding the utilization of the program in their studies related to the interplay between design courses and software usage. These studies demonstrate that the attitude scale and the SUS scale are effective tools for comprehending student impressions of various design methodologies in design education, assessing the usability of design software, and analyzing students' experiences. Both measures offer critical insights for enhancing design education, comprehending student experiences, and refining instructional resources.

The survey of this study was developed based on these studies. The questions were created under the titles of design education, professional life, personal development and contribution to students with relationships between these two drawing methods.

As a third instrument, a mobile AR app has been set up over a two-dimensional (2D) AutoCAD plumbing plan and shared with students to set up on their mobile phones. In the next step, students saw a 3D building structure model with a plumbing line holding their mobile phones over a 2D plan. Then, the survey was shared with students via Google Forms, and the first data was collected this way. Primary data analysis was performed using SPSS 21.0, which included internal reliability and validity tests and correlative analysis. In total, 35 questions were presented to students in a survey under demographic data, conventional drawing, and AR app practice.

Participants

The participants of this study included 121 undergraduate students of Interior Architecture and Environmental Design students at İstanbul Medipol University in Türkiye. 3rd and 4th year Turkish and English volunteer-based 121 students attended the ESBD courses in 2022. While there were sixty-nine attendees in the Turkish Program, there were fifty-two attendees in the English Program. The average age of the participants in the study group is 21.75 years and 81.8% are women. In addition, 57% of the study group participates in the Turkish program. While 76% of the participants stated they were interested in computer and software technologies, 70.2% had never used any AR application. 65.3% of the participants have been in the construction site environment before.

AR app Setup in Interior Plumbing Practice

The AR application used in the study is a marker-based mobile augmented reality app. The application has been designed to work on Android-based smartphones and tablets. The Android platform is preferred because it is relatively common and is easier to adapt to app development kits with open-source codes. The two wet area plans with low flooring shown in Figure 1 were rendered three-dimensional using Autodesk 3D's Max program, and all the sanitary ware elements seen in the plan were added to the relevant areas. The clean water and wastewater installations required by the sanitary ware elements in question were designed according to their technical specifications, coating materials were assigned, and then turned into a three-dimensional environment, as seen in Figure 1.

The next step is to develop the app on the Android platform. Unity platform was used to implement the three-dimensional model into an application. Unity is a real-time software development engine that designs apps and games for Windows, Mac, Android, iOS, and Linux platforms. Camera angles and light settings to be used during the display of the solid model in the Android application were added to the Unity engine as shown in Figure 2. Since the developed application has a pointer feature, a pointer image was added to the Unity platform. In augmented reality applications, the pointer is a method that allows the encoded properties of the model tracked by the mobile device's camera and associated with it to be displayed.

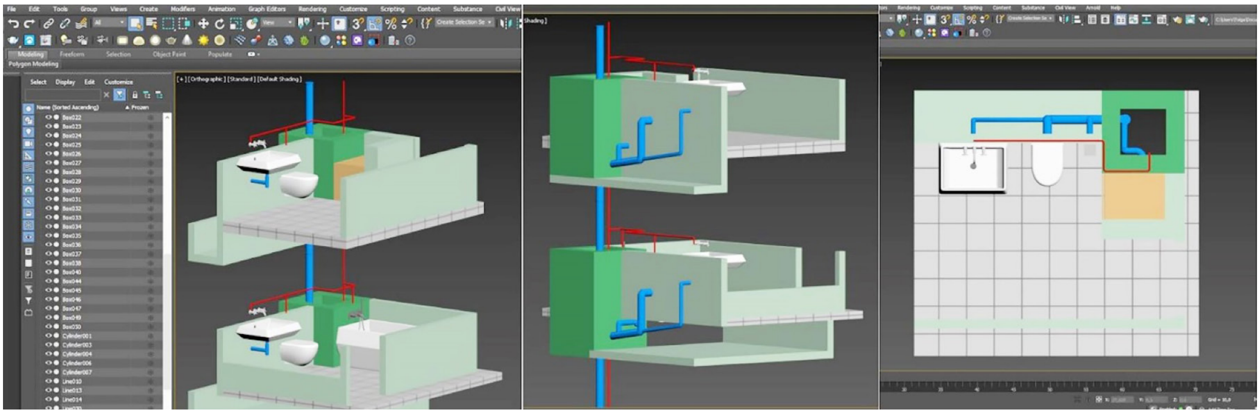

Figure 1. Modeling the plumbing system in 3D's max environment.

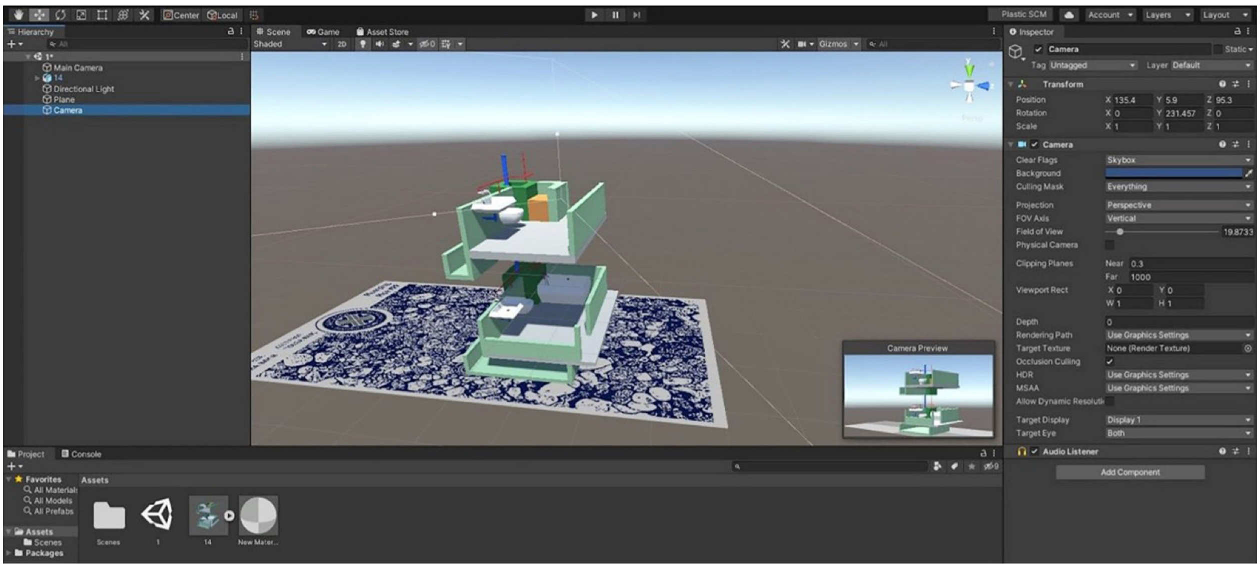

Figure 2. Building the application on the Unity platform.

Pointers facilitate the alignment of physical objects or spaces with the virtual environment and its components. In other words, the pointer transfers whatever digital information is defined in the computer environment to the physical environment.

The marker is connected to Unity software through a software development kit platform called Vuforia Engine. Vuforia Engine (Figure 3) is a programming interface (API) that provides real-time environmental viewing and interaction for mobile or glasses-based AR applications developed in Unity and similar engines. By adding the marker in Figure 4 to the online interface, a database was created. It is essential for the solid model of the mobile application to be displayed accurately in marker-based AR systems. The pointer must be designed to be identifiable by the camera of any Android mobile device.

The database created with Vuforia Engine is associated with Unity Editor in SDK format. The database marker is integrated with the 3D model in the Unity Editor. Following the required adjustments to ambiance, camera viewing angles, and the creation of license codes for the AR experience, the AR application was compiled into the ".apk" format and made available for installation on Android devices.

Students Practices' Experiments

Students experienced firstly conventional (CM), secondly Augmented Reality (ARM) methods and then gave feedback by comparing these two experiences during the lesson in the classroom.

Under the conventional method (CM) experience; students were firstly asked to solve the plumbing structure solution between the two floors, the wet volume apparatus specific to each floor, the relationship between shaft and whole pipes, clean water outlet, and wastewater drain elements in two-story wet areas with different layouts plans and draw them on the plan-section with CM in the plumbing practice. This

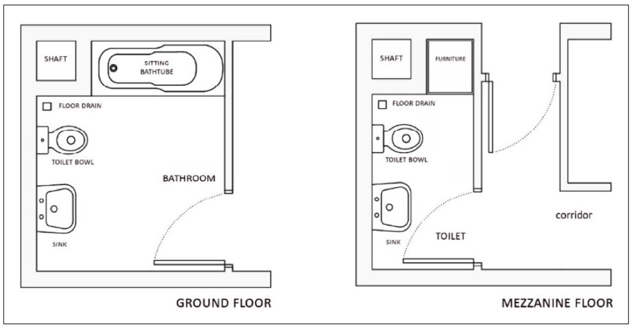

Figure 4. 2D Plumbing Plan on CM (hand drawing) practice.

included placing equipment, detailing the relationships between shafts and pipes, and showing clean and wastewater outlets. This aimed to evaluate their ability to understand and represent plumbing details in a 2D format. Students created hand drawings based on AutoCAD plans. (Figure 4)

Under the Augmented Reality App (ARM) experience, the students installed the 3D version of the plumbing practice created in the AR app on their Android phones. After opening the app, they viewed the plans in 3D by holding their phones over a pattern paper. (Figure 3) They observed the structural water installation solution between the two floors, the points where the clean and wastewater pipes pass in the building, and their relationship with the interior walls, floor, and plumbing chimney. This intended to develop their ability to perceive and understand plumbing systems in 3D. (Figure 5)

At the final step, they compared the 2D hand-drawn layouts (CM) with the 3D views of the placement of the apparatus and the wet area design criteria in the interior layout which they obtained through ARM. And then, they shared their feedback on their understanding and comprehension of the two methods via survey and class conversations. This comparison allowed for the evaluation of each method's strengths and weaknesses and their contribution to their

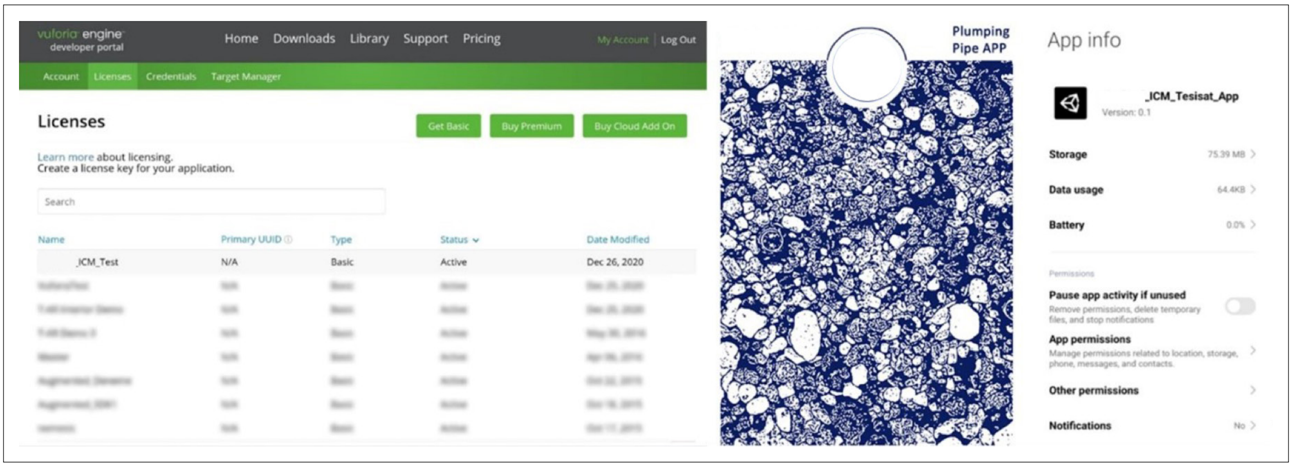

Figure 3. Vuforia Engine, AR marker, and interface of the application.

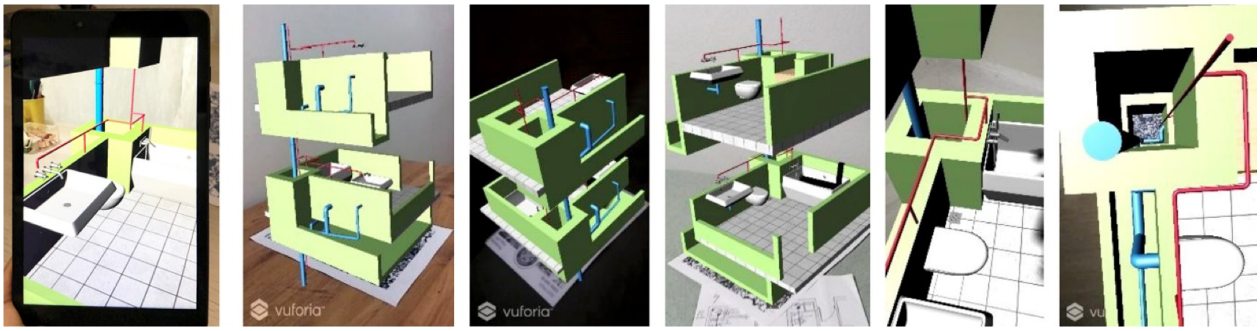

Figure 5. Phone and tablet screens of students during AR app practices.

learning. This facilitated a different perspective that allowed the students to compare the advantages and disadvantages of each method, understand the course content better and improve problem-solving skills. This experience also enabled students to determine the method that suited their learning styles best.

Data Collection and Analysis

During the research process, a scale was applied to the same group of students in which we could question the classical (hand) drawing method (CM) and augmented reality-based application method (ARM) processes together (Yong et al., 2020; Kandil et al., 2021; Vlachogianni &Tselios, 2022; Huang et al., 2023). This scale is commonly used because it is a consistent survey for assessing the AR system in education-based research across various practical disciplines. The questionnaire consists of 11 questions in which each answer is optionally ranked from "strongly disagree" (5) to "strongly agree" (1) based on the questions on the SUS scale (Kaya et al., 2019; Yong et al., 2020; Kandil et al., 2021; Vlachogianni & Tselios, 2022; Huang et al., 2023). The total score was calculated by summing the scores of the answers given on the scale. If a person answered "strongly agree" to every question, the score would be 55, while if he answered strongly disagree to all questions, the score would be 11. The score received by the participants is an indicator of the usability of the system. Participants were explained the purpose and stages of the study, were given written consent forms about the study, and were informed that they could withdraw from the study at any time. Identity information was hidden by assigning pseudonyms to the participants. The data in this study can only be accessed by the researchers. Values outside the normal range were omitted from the study. The study compared the application experiences of students in the CM and ARM practices, examining whether a meaningful relationship could be identified through demographic data. Additionally, feedback from students regarding the interior architecture education process associated with this course was gathered. In this context, some questions, such as demographic data, the relationship between CM and design education/professional life relationship/contribution to personal development, and the AR practice's relationship to design education/professional life relationship/contribution to personal development, were asked to the participants regarding by also taking advantage of SUS scale.

Within the scope of the research, data were processed with SPSS 20.0, including normality, reliability, validity, and t-test analyses. In this process, Cronbach's alpha test was applied to determine the internal consistency of the responses. Cronbach states that the items in the scale with a high alpha coefficient are consistent with each other and consist of items measuring the same feature. The coefficient is expected to exceed 0.7 based on measurements.

In the measurements made, this coefficient was 0.842. Therefore, the measurement is reliable. A normality check determines the analysis method. To perform parametric tests, the data must be normally distributed. Kolmogorov-Smirnov test was applied to check normality. The reason for applying for this test is the size of the study group. For groups larger than 30, the Kolmogorov-Smirnov test is typically used. If the p-value exceeds 0.05, the data is considered normally distributed. As a result of the test, it was determined that this value was less than 0.05. Therefore, the data is not normally distributed. In cases where normal distribution does not occur, non-parametric tests are used. The Wilcoxon test assessed significant differences in the opinions of the same participants in the study group regarding two different situations. This test is used to evaluate the significance of the difference between the scores of two related measurement sets. Demographic information was analyzed using the Kruskal-Wallis H test and the Mann-Whitney U test applied to the variable status. The Kruskal-Wallis H test is a technique used to evaluate the significance of the difference between the means of three or more groups in groups that do not show normal distribution. The Mann-Whitney U test is used to test the significance between the averages of two groups. The mean rank and standard deviation were reported as descriptive statistics for the data obtained, with $p<0.05$ considered as significant.

FINDINGS AND DISCUSSION

To determine whether there was a significant difference between the participants' total scores for the CM and ARM practices, the Wilcoxon sign-rank test was performed because the scores were not normally distributed. When Table 1 is examined, a significant difference was detected between the scores for CM and ARM in favor of AR scores (Z=-3.071; p<0.05). Accordingly, ARM (MR=62.68) applications are more effective than CM (MR=44.08). If the p-value is less than 05, it is considered that there is a significant difference between the two groups. So, there is a significant difference between the applications here. To determine the direction of the significant difference, the mean rank values are examined. The mean rank value indicates a preference for ARM.

The changes in CM and ARM, according to scales of the attitude and SUS, are shown in Table 2. This table shows the result of questions about the relationship between both two methods and design education, professional life, their contribution to personal development, their contribution to the student. In this table, the averages and standard deviations of the answers given by the participants to the questions as descriptive statistics regarding CM and AR applications are presented for each question. Mean values for an item vary between 1-5. It is seen that as it gets closer to 5, the average increases and the opinions become more positive. Table 2 also presents that the AR apps (ARM) have a higher mean score (X) for all questions asked. The results of the question "I need certain knowledge and skills to use in the ESBD course." showed that the averages for the item are close to each other. At this point, AR apps are easier to learn than CM practices. Regarding the question “I think it increases interest in the course.”, it seems that AR apps are more interesting. Regarding the need and advantage of these methods in professional life, the opinion that both methods are necessary was seen with a slight difference (CM X=4.041; AR X=4.190). When examining the impact of applications on personal development, it was observed that the AR app showed effectiveness compared to CM.

Table 1. Wilcoxon test results of CM and ARM practices

CM-ARM*	n	Mean Rank	Sum of Ranks	Z	p
Negative ranks	45	44.08	1983.50	-3.071	0.002
Positive ranks	64	62.68	4011.50		
Equal ranks	12				

* CM: Hand Drawing Practice Method; ARM: Augmented Reality Practice Method.

Table 3 shows the results of the Mann Whitney U test conducted to analyze the differences in the augmented reality (AR) application (ARM) according to demographic characteristics. This analysis examines whether demographic characteristics of the participants, such as gender, program language, whether they came to the department willingly, interest in computer and software technologies, and previous experiences in the construction

Table 2. Descriptive analysis of CM and ARM

Survey questions	CM		ARM	
	X	Standard Deviation	X	Standard Deviation
I find its use in the ESBD* course useful.	4.132	0.806	4.504	0.647
It increases the success of the ESBD course.	4.091	0.894	4.504	0.660
I think it makes learning the ESBD course easier.	4.182	0.827	4.603	0.555
I think it increases the interest in the ESBD course.	3.983	0.940	4.537	0.620
I need certain knowledge and skills to use in ESBD course.	3.620	0.887	3.661	1.084
I think it is a requirement specific to the course.	3.868	0.885	4.050	0.912
I think that this method, which I will use in the ESBD course, will also be useful in other courses.	3.959	0.860	4.397	0.701
I will need these practical methods, which I will in the ESBD course, in my professional life.	4.041	0.889	4.190	0.809
These practical methods that I will use in the ESBD course will provide advantages in my professional life.	4.132	0.774	4.364	0.683
These practical methods, which I will in the ESBD course, increase my interest in the profession.	3.711	0.970	4.140	0.934
These practical methods that I will use in ESBD course increase my self-confidence.	3.661	0.881	4.058	0.897

*ESBD: Environmental Systems Building Dynamic Course; CM: Hand Drawing Practice Method; ARM: Augmented Reality Practice Method.

Table 3. Mann Whitney U-Test results according to the demographic data status of ARM

Demographic data	Group	n	Mean Rank	Sum of Ranks	U	Z	p
Gender	Woman	99	59.02	5843.00	893.000	-1.321	0.186
	Men	22	69.91	1538.00			
Program Language	Turkish	69	69.99	4829.00	1174.000	-3.256	0.001
	English	52	49.08	2552.00			
I came to the department willingly.	Yes	114	61.58	7020.50	332.500	-0.741	0.459
	No	7	51.50	360.50			
I am interested in computer and software technologies.	Yes	92	63.36	5829.00	1505.500	-0.139	0.889
	No	29	53.52	1552.00			
I've been in a real construction site environment before.	Yes	79	57.45	4538.50	1378.500	-1.532	0.126
	No	42	67.68	2842.50			

ARM: Augmented Reality Practice Method.

environment, create a difference in their attitudes towards the AR application. There is no significant difference in the responses given to the AR application according to the gender variable ($Z=-1.321$; $p>0.05$). This shows that female and male students have similar views towards the AR application.

There is also no significant difference according to whether they came to the department willingly or not ($Z=0.741$; $p>0.05$). This result shows that the attitudes of students who chose the department willingly and those who did not are similar towards the AR application. There is also no significant difference according to their interest in computer and software technologies ($Z=-0.139$; $p>0.05$). This shows that students who are interested and not interested in technology have similar views towards the AR application. There is also no significant difference according to their previous experience in a real construction environment ($Z=-1.532$; $p>0.05$). This shows that students with and without construction experience show similar reactions to the AR application. There is a significant difference according to the program language ($Z=-3.256$; $p<0.05$). This difference shows that the attitudes of students in the Turkish program towards the AR application are significantly more positive than those of students in the English program. (Table 3)

Table 4 shows the responses of the question "I think that the CM/ARM that I will use in the ESBD course will also be useful in other courses". Using them in the design studios, detailed analysis in the interior, construction technology, and technical drawing courses would be more beneficial. While it comes to the fore that CM will be more useful in design courses, it is seen that AR app comes to the fore in courses that require detailed drawing/analysis. However, it has been determined that CM will be more beneficial for students in the construction technology course. Although this question is a Likert type, we expected detailed information about the courses from students' comments as an open-ended question. Outliers are extreme values that markedly deviate from other data points in the dataset and can influence the findings of the research. Such values can arise from errors in the data collection process, misunderstandings by participants, or unusual situations. Due to the inadequacy of the responses to open-ended questions, the results that were not significant in SPSS were not included in the table. The low usage rate of AR technology among participants indicates that more effort should be made to popularize this technology in education.

The frequency distribution of possible advantages (A) and disadvantages (D) of AR apps over plumbing practice in

Table 4. Descriptive statistics for the use of CM and ARM in other courses

I think that the method I will use in the ESBD course will be useful in other courses as well	CM		ARM	
	N	%	N	%
Design studio	88	41.90	77	37.56
Detail analysis in interior	59	28.10	62	30.24
Construction technology	40	19.05	39	19.02
Technical drawing	23	10.95	27	13.17

CM: Hand Drawing Practice Method; ARM: Augmented Reality Practice Method.

Table 5. Distribution of advantages and disadvantages of ARM

	Advantage (A) / Disadvantage (D)	Frequency	%
(A)	3D perception	64	35.75
(A)	plumbing solution	20	11.17
(A)	relationship between structure and plumbing	33	18.44
(A)	relationship between space and wet area design	12	6.70
(A)	diameter dimensions and differences of clean/wastewater pipes are understood	16	8.94
(A)	it reduces learning time and provides ease of understanding	27	15.08
(D)	more interior details should be given	4	2.23
(D)	No paper should be needed to use the app	1	0.56
(D)	flexibility of movement / if there was something other than a phone	2	1.12

ARM: Augmented Reality Practice Method.

open-ended questions is presented in Table 5. Participants stated six advantages and three disadvantages of AR apps. When the table is examined, the most advantageous areas were 3D perception with 35.75%, followed by 18.44% understanding the structure-installation relationship and 15.08% reducing the learning time/easiness in understanding.

94.2% of the participants think that using this AR app will be advantageous in terms of course topics. However, some participants think that it has some disadvantages. They provided some suggestions for fixing current problems with the AR app. The application could be advantageous if more interior details are given, it can be used without paper, and it is supported with interventions such as flexibility of movement using an instrument other than the phone.

CONCLUSION

This study explored the use of Augmented Reality (AR) technology in interior plumbing drawing practices within the Environmental Systems Building Dynamic (ESBD) course in interior architecture education. The aim was to enhance students' 3D perception of building-indoor elements and the relationship between structure and installations, thereby improving the understandability of the applications. The study examined the "effect of integrating AR technology into 2D drawing applications on student participation, comprehension, and problem-solving skills". Two drawing methods-conventional technical drawing (CM) and AR-based experimental practice (ARM)-were compared. Students experienced the AR app on their mobile phones. Then, they had a questionnaire via Google Forms to evaluate the usability scores of mobile AR app on the Android system.

According to the survey, demographic factors such as gender, department preference, and previous construction site experience exhibited minimal impact on interest in ARM. Turkish program students and individuals with prior construction experience exhibited greater engagement with AR ($Z=-3.256$; $p<0.05$).

Augmented reality demonstrated the highest effectiveness in "3D perception" at 35.5%, followed by "structure-plumbing relationships" at 18.44%, and "ease of understanding" at 15.04%. When comparing CM and ARM in the ESBD course, students rated ARM higher in design-education integration (CM: MR=44.08; ARM: MR=62.68). ARM has been shown to enhance learning and boost engagement in the course.

The open-ended responses indicated that the most beneficial aspect of the ARM was 3D perception, accounting for 35.75%. ARM was seen to provide high benefits in understanding the relationship between the structure and plumbing (18.44%) and reducing learning time and ease of understanding (15.08%). They stated that both CM and ARM methods are necessary for the ESBD (Environmental Systems Building Dynamic) course. They believe that the course should be supported by the ARM method as well as CM.

According to student experiences, through ARM, students gained a more detailed and relational understanding of plumbing systems. They particularly grasped the connections between structural water installations, the passage of pipes, and their interaction with interior elements. The 3D visualization offered by ARM helped students better perceive the complexities of the plumbing systems. This was significant, especially in understanding the relationship between space and wet area design. The opportunity to view the 2D CM drawings in 3D via ARM made the learning processes more effective. This allowed students to compare both methods and determine which suited their learning styles.

Moreover, it has been seen that ARM has the potential advantage over the other outcomes that are expected to be understood by students in this drawing practice, such as plumbing solutions, diameter dimensions, differences between clean/wastewater pipes, and the relationship between space and wet area design. Although this method has significant advantages in terms of course outcomes, the AR apps should be improved in some respects, including the level of detail in a virtual 3D environment, using pattern paper, flexibility, and diversity of devices.

When the contribution of this study conducted within the scope of ESBD courses to other courses is examined, it comes to the fore that CM would be more useful in designing essential courses. However, ARM comes to the fore in courses that require detailed drawing/analysis. CM proved to be especially useful in the "construction technology" course. The opinion was that the AR app would be useful in all courses requiring 3D perception, but it was also detected in open-ended questions that ARM should still be supported with CM.

Integrating AR technology into plumbing teaching aims to improve the education of interior architecture students and equip them with the knowledge and skills required to create environmentally friendly, water-efficient, and sustainable interiors. This research also contributes to innovative pedagogical methods in interior architecture education by emphasizing the transformative potential of technology in shaping the future of interior architecture drawing practices. In addition, the study also underlines the critical role of this technology in shaping the future of interior architecture education and the interior architecture industry.

This study emphasizes the transformative potential of augmented reality in influencing education and the interior architecture sector. Students recognized that both methods facilitate personal and professional development, with augmented reality exerting a more significant influence on confidence and sectoral preparedness. Both methods are necessary; however, AR is recognized as more beneficial for professional applications.

In the future, this study will continue to be applied to students of different programs and age groups. The current study's survey scale, app, virtual environment, and contents will be improved by enhancing the students' feedback and possible deficiencies they reported. The parameters that change or remain constant in students' attitudes towards in-class practices will be re-evaluated and investigated through these improvements in this course. Ways to increase students' interest and efficiency in this course will be continued with the aim of measuring students' future attitudes through in-class learning outcomes and developmental studies on adaptation to technology.

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