INTEGRATING AR INTO A GRAPHIC DESIGN PROGRAM FOR AN ENHANCED DESIGN CURRICULUM

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ABSTRACT
The continued interest in augmented reality (AR) applications in the business sector has precipitated a corresponding surge of design with AR in the design industry. In turn, the rise of AR in the design profession requires a proactive response from design education. Upon that foundation, this paper introduces a pioneering pedagogical approach integrating AR into a foundational 2D graphic design course, aiming to expand students' digital capacity, foster an understanding of design thinking, and cultivate problem-solving skills. This paper outlines the AR-enhanced project and assesses its pedagogical efficacy based on student surveys conducted at the end of the project, including the challenges encountered along the way and positive suggestions for the specific learning context. We aim to share insights from the teaching experience and provide educational institutions with a valuable reference for advancing their curricular approaches.

Keywords: Augmented reality, AR, graphic design

1 INTRODUCTION
Augmented reality (AR) has recently transitioned from a mere technological fascination into a practical tool embraced by the business sector [1]. The shift indicates the ongoing integration of AR applications into the mainstream of the design industry, prompting a call for a corresponding curriculum in design education. Recent scholarly research on AR in design education has showcased early initiatives for the pedagogical use of AR [2] across design-related disciplines. This paper presents a comprehensive assessment of AR's potential as a pedagogical tool in graphic design foundation for achieving learning objectives, including enhancing students' technological competencies, deepening understanding design theory, and cultivating problem-solving skills through immersive design processes. We conducted course surveys to evaluate students' learning experiences in meeting the learning objectives. This paper validates and reaffirms AR's role as a pedagogical instrument, underscoring higher education's adaptability in responding to the demands of the digital age.

2 AR AND ITS PRACTICE IN THE DESIGN INDUSTRY AND EDUCATION
The meaning of AR differs depending on the perspective taken [3]. For instance, Wellner et al. [4], in an action-oriented approach, defined AR as a system that overlays computer-generated information onto real-world environments. In another case, Azuma [5] described AR from an objectivist standpoint as a system in which "the virtual and real objects coexist in the same space" (5: 356). Pragmatic researchers such as Ghazwani and Smith [6], then regarded AR as a tool that enables users to observe virtual objects integrated into the real world in real time, placing particular emphasis on AR's potential usability. However, within the creative industry, AR has been viewed as a creative technology rich in various digital media in a virtual space [7]. A number of professional studios, such as *NEEEU Spaces* [1] and *Arcade,* the one spotlighted on the Zap Work showcase, have utilised AR to address real world design problems, indicating the rise of AR in professional design practice. Although AR remains relatively rare in mainstream design, the growing examples from the design profession have affirmed AR as a design medium endowed with considerable creative potential.
The growing practice of AR in the design industry calls for a response from design education [2]. However, unlike the professionals in the design industry, educators approached AR as a principle of augmentation rather than a mere innovative technology. Wu [3] argued that viewing AR as a concept is

more productive for educators, suggesting a focus on the idea of augmentation to pedagogically enhance students' learning experience. Abidin et al. [8], for example, experimented with AR to augment the presentations of student interior design projects. At Queensland University of Technology in Australia, Kerr and Lawson [9] developed an AR-featured project, "Master of Time," to help first-year students in landscape architecture "create new practices in digital storytelling" (9: 6). These examples in design education reflect Korani et al.'s [2] assertion that AR is not only a creative technology in the design industry but more about a pedagogical tool that facilitates design learning in education.

3 AR TOOLS AND ACCESSIBILITY

Coding requirements in AR tools have remained a major challenge for design students, as pointed out by Abidin [8]. However, the ubiquity of smartphones and high-speed internet connectivity has paved the way for mobile-based and web-based AR platforms, making AR increasingly accessible to a broader audience. Zap Works Designer, released in 2021, and Adobe Aero, introduced in 2019, are both mobile and web accessible. Both offer a designer-friendly approach to creating, viewing, and sharing interactive AR content on smartphones. Zap Works Designer, in particular, promises a "no apps, no downloads, and no coding" approach, serving as a gateway for embedding AR into design education, and asserts itself as a ready, approachable tool for design students in studio settings. For those reasons, we chose Zap Works Designer to facilitate the AR-enhanced project in this study.

4 LEARNING OBJECTIVES

4.1 Expanding digital capacity

The digital content overlaid on the real-world objects through an AR tool, such as Zap Works Designer, involves various media applications, including digital text, 2D images, audio, video, 3D models, and animation. When incorporated into a studio course, AR can become a conduit for students to explore diverse forms of digital media. Through a hands-on project featuring AR, students will explore specialised file formats, data exchange and transfer, and digital practices commonly utilised in AR applications and game design but less prevalent in traditional graphic design practices. Since the key to using multiple digital media is integration and adaptability [11], and for that reason, the approach involves collaborative endeavours exploring 2D, 3D, audio, video, and animation can develop and enhance students' technological knowledge and skills for interoperability workflows and expanded collaboration [12]. As the demand for print materials continues to decline and virtual interactivity is gaining prominence [2], such enhanced digital proficiency equips design students with the adaptability required to navigate the evolving landscape of the digital era.

4.2 Fostering design thinking

As a technology and form of knowledge beyond the conventional boundaries of graphic design, AR supports students in comprehending design thinking as a boundary-pushing approach widely discussed in recent design literature. Design thinking is not merely a mindset but a structured method of seeking innovation outside conventional norms, akin to what Cross [13] has described as solving problems from a "completely different angle" (13: 11). This structured method features a strategic framework centred on boundary-pushing, seeking creative opportunities for problem-solving outside the given discipline [14]. Wang [15] noted that by engaging with a different subject or type of expertise, often from a distant field, designers gain fresh perspectives that enable them to scrutinise design problems from novel angles.

In design education, exploring AR beyond the constraints of the 2D grid in graphic design resonates with the design thinking framework. Such experimentation prompts students to explore AR as a creative medium beyond the traditional realm of graphic design. In turn, students can grasp design thinking as a boundary-breaking approach, examining graphic design problems from AR's perspective to address them innovatively. The learning experience helps students understand design thinking as a design method. However, in the long term, this approach serves as a stepping stone for shifting students' focus from formal aesthetics in the foundational study, as occurred in the past, to innovative problem-solving, which is highly valued in graphic design learning and practice.

4.3 Enhancing problem-solving design skills

Integrating AR into a graphic design project immerses students in a collaborative design practice in which they constantly need to decide the reasons and methods for interoperating between various

platforms, utilising cross-media tools, and converting different digital files. This multidisciplinary or, more accurately, the transdisciplinary design process requires students to proceed with goals and purposes aimed at problem-solving. The design experience mirrors the concept of "design by immersion" as introduced by Hall et al. [16], in which designing within multiple disciplines is viewed as an immersive design process that "captures and supports transdisciplinary approaches to problem-driven visualisation" (16: 110), a method "well suited to problem-driven visualisation work" (16: 109), and "a way to transform and enrich knowledge and skills through a transdisciplinary experience" (16: 111).

Given that multidisciplinary practice has always been inherent in design and is increasingly recognised in the field [17], the AR-integrated multidisciplinary design process not only encourages students to focus on design problem-solving but also enhances their design knowledge and skills during their foundational training. Furthermore, it offers an early indication of the future direction of design, which involves a more collaborative, multidisciplinary approach. Indeed, this trend is evident in today's expanding design boundaries, the growth of user experience (UX) design, AR, and emerging design practices utilising generative artificial intelligence (AI). While the learning experience may pose challenges for entry-level students by requiring increased cognitive attention to multiple disciplines, it can foster an open, flexible, and creative mindset, mitigating the risk of students developing rigid preferences solely focused on print design during their early learning stages.

5 METHODS

To explore AR's potential in graphic design, we conducted a pilot study by integrating AR into a poster design project in a foundational studio course comprised of two sections of second-year college students in the graphic and information design program at a state public university. Prior to the AR-integrated task, students in foundation studies often took on an aesthetic-centred approach, emphasising design principles and enthusiastically pursuing visual appeal. This AR-enhanced poster design project, however, asked students to incorporate AR (Zap Works Designer) in graphic design to add an interactive dimension to encourage a problem-solving driven design strategy.

The course, spanning six weeks with two-hour sessions held twice weekly, featured a fully guided teaching approach given its foundational nature. It included three phases: Phase 1, lasting two weeks, focused on introducing graphic design principles and the poster project alongside lectures on Augmented Reality (AR) applications. Phase 2, a one-week segment, introduced design thinking methodologies through studio seminars. Lastly, Phase 3, spanning three weeks, centred on digital workflow, tutorials on Zap Works Designer, and studio critiques, immersing students in a multidisciplinary design process (Figure 1).

Figure 1. Students experimenting with AR using Zap Works Designer in a design lab

Upon the conclusion of the project, a survey utilising Likert scale, true-and-false, and open-text responses was administered to students to evaluate the learning objectives based on their experience, including the challenges encountered in the study. Class observations were included to complement the assessment, shedding light on the learning experience. The survey additionally incorporated questions aligned with the CT-PAF evaluation framework to assess the pedagogical effectiveness of Zap Works Designer as an educational multimedia tool in this practice. CT-PAF is a framework that aims to help educators assess technological learning tools regarding their pedagogical impact and outcomes [18].

6 DISCUSSIONS

6.1 Success

Twenty-three students in the class responded to the survey. All students except for one reported having an enhanced understanding of digital file formats, data transformation, and cross-platform interoperability following the completion of the project. Such an improved understanding empowered students with a broader digital skill set, for it encouraged students to explore various techniques, styles, and mediums and thus prepared them to be more productive and efficient as they took continuously advanced design courses. Moreover, knowing diverse digital media resources beyond the confines of Adobe 2D tools such as Illustrator and Photoshop prevented students from confining themselves in a print-only design comfort zone. It opened more creative opportunities and expanded students' perception of design via a collaborative approach that leverages various digital platforms and types of technology. Such a holistic approach equipped students with the versatility and agility needed to step into their future careers and thrive in an increasingly digital-centric professional landscape.

For a foundational design course, design thinking is undoubtedly an advanced theory. Thus, negative feedback from students was anticipated when the theory was introduced alongside the AR-integrated project. However, the survey results were nearly unanimous in both course sections positively regarding their enhanced understanding of design thinking and its role in driving creativity. By incorporating AR into a graphic design project, students were able to experiment with design thinking as a methodological approach, thereby expanding the boundaries of graphic design from traditional 2D formats to include AR technology to solve the assigned design problem: engaging visitors in a museum event by providing an immersive experience. Despite the perception that introducing design theory was premature and diverged from conventions of advanced studies in design theory, understanding design thinking benefited students in the study by instilling in them an open mindset characterised by inclusivity, curiosity, risk-taking, and flexibility, all of which are valuable within the very realm of design education. We proposed that an immersive design experience would cultivate students a problem-solving mindset and skills, as discussed in Section 4.3. However, the survey showed that four students disagreed for various reasons; one expressed the need for more AR practice, and another commented on a lack of connection between AR and problem-solving in design. Nevertheless, most students (n=19) agreed that the project helped them develop problem-solving skills. For instance, one student commented, "I believe the [AR] design experience helped me with my problem-solving skills because it challenged me to find a solution." Exploring AR alongside graphic design involved collaboration across platforms, software, and tools, making the AR-enhanced project a transdisciplinary design process. That transdisciplinary approach was driven by design reasoning, for students continually needed to justify the use of multiple tools and platforms with goals for solving problems in poster design, thereby preventing them from focusing solely on the visual appeal of the poster. After all, problem-solving through design is integral to modern design and will continue to be emphasised in design education, especially in increasingly tech-driven climates. In that sense, the project transcended mere aesthetic practices as was once common in the course by serving as a catalyst for developing a proactive vision within graphic design studies. As one student remarked in the survey, "It helped us to get a heads-up on assignments in the future," the study facilitated a shift from focusing solely on visual appeal or "eye candy" to a problem-solving-centred design strategy much valued in design education and the design industry.

6.2 Challenges

The survey revealed two primary challenges encountered by students during the AR-integrated practice: significant cognitive attention required for the task and the short time frame, which intensified these challenges. Although all students in the study agreed that Zap Works Designer was user-friendly, a significant number of them found the learning experience in this project to be somewhat overwhelming. Some reported experiencing considerable cognitive challenges, and only a minority of students expressed feelings of ease and comfort during the learning. Several students described that this practice involves not only a novel tool to learn but also a new hybrid design process never experienced before. Beyond that, some students voiced concerns that the six-week time frame for the AR-integrated project was insufficient, despite recognising AR's potential benefits in pedagogy.

Upon reflection after the completion of the project, we acknowledged the disadvantages of the approach. Learning to use a new AR tool while mastering design principles indeed required students to navigate multiple tools simultaneously, leading to increased cognitive demand. Extending the project's time frame, depending on the course schedule, and providing additional guided workshop hours could

alleviate some of the learning pressures and mitigate the intensity of the learning experience during the learning process.

6.3 Evaluating Zap Works Designer based on the CT-PAF evaluation framework.

An evaluation method explicitly tailored for assessing technology adopted in visual design is rare in the design literature. To evaluate the AR tool utilised in the project, we developed an evaluation rubric based on the CT-PAF framework. CT-PAF is an assessment system devised by Oyelere et al. [18] to gauge the pedagogical effectiveness of computer thinking tools. We adapted part of its evaluation indicators to evaluate the AR tool used in the project (see table 1). On the student survey, questions were thus tailored according to those indicators to gain insights into selecting AR tools that could be used for similar tasks. Table 1 presents the evaluation results corroborated by students' feedback on their learning experiences.

Table 1. Assessment of Zap Works Designer based on students' learning experiences

Indicator/Criteria	Evaluation
Purpose of the tool	The designer-friendly tool is used to create highly accessible interactive AR content using a smartphone without coding.
Ease of use	During the task, 90% of students in the task considered Zap Works Designer to be an easy tool to use.
Ease of learning	95% students find the tool is easy to learn since it is coding free, simple in interface, and has steep/short learning curve.
Satisfaction	The interactive AR content was engaging, and 90% of students expressed satisfaction with the results of using the tool.
Perceived usefulness	The tool was used to enhance the interactivity of print design and as a pedagogical tool for design learning; 75% of students evaluated it as useful for enhancing their design work, and 65% considered it useful for education purposes.
Recommendation	Students learned how to use a new interactive tool for design, and 80% of students reported that they would recommend the tool to others.
Availability for teaching	A free two-weeks trial and an affordable educator account are available for class teaching purpose.

Overall, the feedback was positive and reflected students' favourable learning experiences with Zap Works Designer. Many students found the AR toolkit easy to use and cited its simple interface and no-coding-needed feature as key factors. That observation aligns with the findings of Abidin et al. [8], who noted in their interior design class that AR tools devoid of scripting work are more conducive and productive for design students. Satisfaction was measured by the design's final outcome with AR, and the majority of students found the results intriguing and gratifying. They were particularly pleased with their ability to interact with the AR content by using their smartphones to scan their own print design work, which not only gives their work technological breadth but also makes a rich and diverse design portfolio for personal promotion. Moreover, most students expressed interest in using the AR tool beyond the project and recommended the tool to other students. Last, regarding accessibility for teaching purposes, the AR tool used in this project supports education by providing affordable education accounts that facilitate its integration into classroom teaching.

7 CONCLUSIONS

By the conclusion of the course, students are expected to have acquired a deeper appreciation for the value of AR in graphic design. The AR-enhanced pedagogical task demonstrated its capacity to cultivate an open mindset among students, encouraging them to embrace technology within the realm of graphic design. This inclusive approach is particularly pertinent in an era when new media are increasingly reshaping the landscape of the graphic design profession. Since the task was implemented in a lower-level design course, future studies should explore further integrating AR into upper-level design courses,

particularly those centred on 3D imaging, motion graphics, and animation. Such exploration can provide a more comprehensive understanding of AR's potential in the current curricula in design education.

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