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Editorial Board

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Prof. Siu-Tsen Shen
Editor-in-Chief

We are pleased to introduce the tenth edition of the International Journal of Multimedia Art, Design and Education (MADE). As an open-access, peer-reviewed resource, MADE remains committed to publishing premier research across the diverse landscape of design.

In mid-January 2026, the global landscape is marked by profound instability in both Venezuela and Iran. Venezuela is navigating a high-stakes transition following the U.S.-led Operation Absolute Resolve, which resulted in the capture of Nicolás Maduro to face narcoterrorism charges in New York. While Delcy Rodríguez serves as interim president, the U.S. maintains significant influence over the country's energy infrastructure and phased transition, amid deep international divisions over the intervention's legality [1].

Simultaneously, Iran is facing a historic nationwide uprising triggered by a collapsing economy and a record-low Rial. These protests have escalated into a direct challenge to theocratic rule across all 31 provinces. The regime has responded with a total internet blackout and a violent crackdown, with human rights monitors estimating thousands of fatalities and over 16,000 arrests [2].

In these challenging and turbulent times, our collective responsibility becomes clear. The International Journal of Multimedia Art, Design and Education (MADE) believes in the power of design to foster sustainable economic growth and create essential pathways for the next generation of leaders. It is only through the collaborative effort showcased in these pages that we can effectively face global hurdles—spanning from post-pandemic recovery and ongoing recessionary pressures to the specific crises unfolding in Iran and Venezuela, and broader geopolitical instability—thereby building a more resilient, equitable future for all.

Acknowledgements

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Prof. Siu-Tsen Shen

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The Use of ChatGPT Among AFL Freshmen in a *Tour Manager and Tour Guide* English Class

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This study aimed to examine the use of ChatGPT among 52 freshmen enrolled in the Applied Foreign Languages (AFL) program, specifically within a *Tour Manager and Tour Guide English* course in Taiwan. Data were collected through an online questionnaire designed to explore students' perceptions of ChatGPT in completing course-related tasks in an English-language classroom. The central research question guiding the study was: *How did Taiwanese AFL freshmen perceive the use of ChatGPT in completing course-related tasks within an English-language classroom?* The findings revealed several key insights: (a) Both users and non-users of ChatGPT generally agreed that the tool is easy to use, with 98.1% of all participants indicating a willingness to use it in future learning contexts; (b) Among ChatGPT users, there was a high level of satisfaction, particularly in terms of ease of use, increased efficiency in completing homework, rapid access to information and answers, and the generation of diverse ideas; (c) Conversely, non-users expressed more concerns about the tool's limitations—especially inconsistencies in responses to the same question and the need to restructure or verify generated content. Despite these reservations, all non-users indicated a willingness to use ChatGPT in future academic settings. This study contributes to the growing body of research on the integration of AI tools in language education by providing insights into learner perceptions, highlighting both the benefits and challenges of ChatGPT use. It also offers practical implications for instructional design, suggesting the need for pedagogical strategies that support effective and critical engagement with AI technologies in the language learning classroom.

Keywords - Applied Foreign Languages (AFL); ChatGPT; Taiwan; *Tour Manager and Tour Guide English.*

Relevance to Design Practice - ChatGPT can be a useful design tool for language teaching and learning.

Introduction

Research Background

Taiker Team (2023) reported that the frequency of Chat Generative Pre-trained Transformer (ChatGPT) usage among undergraduate students worldwide was lower during the summer vacation of 2023 compared to the spring and fall semesters. The findings suggest that students are more likely to utilize ChatGPT for completing coursework and academic assignments during active academic terms. Consequently, examining the advantages and disadvantages of ChatGPT use in undergraduate academic work warrants further investigation.

Since its launch by OpenAI at the end of 2022 (Ali et al., 2023; He, 2023; Montenegro-Rueda et al., 2023), ChatGPT—based on natural language processing (NLP) technologies and large language models capable of language comprehension and text generation (Brants et al., 2007)—has attracted significant global attention and sparked widespread discussion (Aydın Yıldız, 2023; Kao, 2023; Syu, 2023). As a tool with the potential to support student learning (Fuchs & Aguilos, 2023), ChatGPT offers assistance that was previously unavailable. Traditionally, students spent considerable time collecting and organizing information for their coursework (Lee, 2023) and often faced delays in receiving help from instructors when encountering academic difficulties. In contrast, ChatGPT allows users to generate information quickly and in various formats, significantly reducing the time and effort required (AlAfnan et al., 2023; Farrokhnia et al., 2023; Fuchs & Aguilos, 2023; Lee, 2023). Unsurprisingly, many students have begun using ChatGPT to support their academic work. By simply entering a few keywords, they can obtain comprehensive answers or even full-length articles within seconds (Lee, 2023).

However, the rapid integration of ChatGPT into educational contexts presents several challenges. Concerns include the accuracy of the generated content (Ngo, 2023), the risk of over-reliance on AI tools (AlAfnan et al., 2023), diminished interpersonal engagement, potential biases and discriminatory content (Fuchs, 2023), and linguistic limitations (Wilkenfeld et al., 2022). Educators increasingly express concern that heavy dependence on ChatGPT may undermine students' opportunities to engage in independent thinking, thereby impairing their capacity for critical and autonomous learning (Farrokhnia et al., 2023; Kao, 2023).

Research Purpose and Research Question

In this era of rapid AI advancement, exemplified by tools such as ChatGPT and Copilot, sustaining student learning effectiveness has become a pressing issue in educational discourse (Kao, 2023). Therefore, further investigation into ChatGPT-related research is warranted.

The present study aims to examine the perceptions of Taiwanese freshmen majoring in Applied Foreign Languages (AFL) regarding their use of ChatGPT in

completing coursework for the course *Tour Manager and Tour Guide English*. In this context, "coursework" encompasses a range of academic tasks, including the mid-term examination, homework assignments, in-class brainstorming papers, and related activities. The central research question guiding this investigation is: *How did Taiwanese AFL freshmen perceive the use of ChatGPT in completing course-related tasks within an English-language classroom?*

Literature Review

Relevant Literature

As the term implies, *ChatGPT* refers to a Generative Pre-trained Transformer (GPT) system designed for online interactions (Syu, 2023). ChatGPT, such as GPT-3.5 developed by OpenAI, is a natural language processing (NLP) model that leverages deep learning techniques to recognize associations between words and phrases, enabling it to generate text that closely resembles human language (Gilson et al., 2023; Syu, 2023). To be more specific, ChatGPT is capable of producing extensive responses to user queries (Ngo, 2023), writing code, translating articles, and generating a wide range of content such as academic papers, screenplays, novels, and prompts (Syu, 2023). Beyond information retrieval, ChatGPT can synthesize and interpret knowledge, offering diverse perspectives in its responses (Kao, 2023).

Compared to conventional virtual assistants such as Google Assistant or Siri—which function based on predefined databases and fixed algorithms—ChatGPT represents a significantly more advanced form of artificial intelligence (Syu, 2023). Generative AI systems like ChatGPT can produce a wide array of content, including text, images, and music (Ngo, 2023; Syu, 2023).

However, the outputs are not always accurate and may include misinformation or fabricated content, which can appear convincing due to the nature of generative language models (Gilson et al., 2023; Syu, 2023). Additionally, such systems are susceptible to generating biased content, as they may reflect the underlying societal biases—such as those related to gender or race—present in their training data (Farrokhnia et al., 2023; Gilson et al., 2023; Syu, 2023). Due to these risks, industries—particularly in finance—have expressed concerns regarding the use of generative AI, especially in relation to legal compliance, protection of proprietary information, and cybersecurity (Syu, 2023). Similar caution is observed across various sectors when integrating emerging digital technologies such as generative AI (Syu, 2023).

Previous Studies

Farrokhnia et al. (2023) employed SWOT analysis framework to review and analyze scientific literature in education. The strengths of ChatGPT include producing plausible contents, boosting self-improving ability, supplying personalized responses and offering immediate answers. The weaknesses of the tool encompass lacking profound

comprehension of specific materials, having difficulty in assessing the quality and reliability of generated content, involving the possibility of bias and discrimination, and reducing higher-order cognitive stimuli. The opportunities of the tool involve democratizing information, enhancing personalized acquisition, increasing intricate learning, and reducing teaching workload. The threats of the tool come in producing varieties of risks resulting from a lack of deep understanding of generated context, posing challenges in academic ethics and integrity, giving rise to prejudice and discrimination in education because of biased and/or wrong information, conducting plagiarism in academy, and weakening higher-order thinking skills.

Ngo (2023) investigated the voices of 200 Vietnamese college students about the use of ChatGPT for learning. Data collection included an online survey and semi-structured interviews with 30 students. The research results indicated that (a) The participants tended to take a favorable attitude toward ChatGPT, including using the tool easily, saving time, offering information of various fields, supplying personalized learning and feedback, and generating ideas for writing, (b) Several students may commit plagiarism because they lacked the ability to evaluate the quality and reliability of generated texts and to cite information properly, and (c) Academic ethics and integrity should be rooted in students' minds in academy.

Ye (2023) reported that Chung Yuan Christian University (CYCU) conducted a survey on the assistance and impact of ChatGPT on education among CYCU teachers and students. From March 8 to 10, 2023, 1,101 questionnaires were collected. Sixty-six percent of students and 62% of teachers had experience using ChatGPT. Students thought that ChatGPT could help them to grasp key summaries (31%), translate articles (28%), and write assignments and reports (24%). Some students considered ChatGPT as a model reference tool, which helped save time and performed better in translation than Google. However, some students were worried that they might become too dependent on it and lose their ability to study or think independently. Most importantly, CYCU was open-minded to encourage students to make good use of AI tools such as ChatGPT, and at the same time, strengthen the assessment of learning achievements and teach students to use these tools in an ethical manner.

Research Gap and Contribution

Unlike previous studies on the use of ChatGPT, which often examined general educational settings, the present study specifically investigates its application within the context of the course *Tour Manager and Tour Guide English*, offered to freshmen majoring in Applied Foreign Languages (AFL). The study also distinguishes between two participant groups: ChatGPT users and non-users. These distinctions provide a more concrete and context-sensitive examination of ChatGPT's

role in academic work, recognizing that its use may differ depending on academic discipline, course content, or learning environment. Therefore, this study offers a valuable contribution to the field of English language teaching and learning by addressing a research gap concerning how and why college students use ChatGPT to complete coursework in a specific, discipline-related context.

Methodology

Participants

Using convenience sampling, a total of 57 freshmen majoring in Applied Foreign Languages (AFL) and enrolled in the elective course *Tour Manager and Tour Guide English* at a national technical university in mid-southern Taiwan participated in the online survey. Of these, 52 valid responses were collected, yielding a high response rate of 91.2%. Five questionnaires were deemed invalid, as four male and one female participant responded to item 19: "If you rate this item, your questionnaire will be invalid."

Thus, the final sample consisted of 52 AFL freshmen (Male = 5, 9.6%; Female = 47, 90.4%). Regarding English proficiency, as measured by the TOEIC, 5 students (9.6%) had scores above 700, 34 students (65.4%) had scores below 700, and 13 students (25.0%) had not yet taken the TOEIC. In terms of ChatGPT usage, 41 students (78.8%) reported using ChatGPT during the course, while 11 students (21.2%) did not. Furthermore, 51 participants (98.1%) expressed willingness to use ChatGPT in future learning contexts, with only one female student (1.9%) indicating otherwise.

Table 1. Participants' Demographics

Characteristic	Classification	Numbers	Percentage
Gender	Male	5	9.6%
	Female	47	90.4%
	Others	0	0.0%
English level (TOEIC score)	≧ 700	5	9.6%
	< 700	34	65.4%
	Taking no test	13	25.0%
Did you use ChatGPT in the course?	Yes	41	78.8%
	No	11	21.2%
I will use ChatGPT in the future.	Yes	51	98.1%
	No	1	1.9%

Course Assignments

In this elective course, course assignments included six in-class group brainstorming assignments and mid-term exam. As part of the course assignments, participants had the opportunity to use ChatGPT for several tasks,

including six group brainstorming writing assignments and the take-home mid-term exam. The six in-class group assignments included their experiences or feelings about some scenic spots in Taiwan mentioned in the textbook (e.g., Taipei National Palace Museum, Longshan Temple, Baoan Temple, and the Tainan Confucius Temple) and tourism-related English dialogue creating (e.g., airport check-in scenario, customs dialogue, and in-flight English conversation). The midterm exam encouraged the students to create their VC (Virtual Character)-related English dialogue-based hometown introduction scripts.

However, the final exam, a non-writing assignment, was excluded from this current study because the students did not have the chance to use ChatGPT for the last assignment. To be more specific, students' mid-term exam scripts were recorded as a final exam via Virtual Avatar Interactive Live Streaming System (VAILSS) which was designed by another instructor-researcher and employed in his lab office.

Questionnaire

The completion and collection process of the 6-point Likert scale online questionnaire (https://forms.gle/dmJzghwRFUQe5DJRA) are outlined in Table 2. Initially, to design the questionnaire items, the interview data from 22 AFL undergraduate students (M=12; F=10) were collected through IG (Instagram) (n=3), FB (Facebook) (n=3) and LINE (n=16) in approximately two weeks (from September 19 to October 3 of 2023). Thereafter, a brainstorming meeting involving 6 researchers was conducted to further refine these identified main issues for the current study. Following this, a pilot paper questionnaire survey was administered to 25 AFL college students, consisting of 10 males and 15 females, to further determine the primary issues.

Furthermore, the researchers invited a Chinese instructor with over 10 years of teaching experience at the same technical university to evaluate the validity of the questionnaire items. Subsequently, an online pilot rating was conducted by five researchers to ensure the smooth execution of the rating process.

Finally, in the official questionnaire rating stage, data were collected from a total of 57 participants, with 52 providing valid responses that were included in the analysis. The other five participants provided invalid responses because they rated questionnaire item 19 for ChatGPT users or item 20 for non-users, "If you rate this item, your questionnaire will be invalid." Hence, the valid rate arrived at 91.2%.

Table 2. Completion and Collection of Questionnaire

No.	Technique	Purpose	Participant (n)
1	interviews via media	identification of main issues	22 AFL college students (M=12; F=10)
2	brainstorming	identification of main issues	6 researchers
3	pilot paper questionnaire rating	identification of main issues	25 AFL college students (M=10; F=15)
4	expert validity	validity of questionnaire	1 Chinese instructor
5.	pilot rating online	rating smoothly	5 researchers
6	official questionnaire rating	data collection	57 raters (valid: 52)

The online questionnaire included three parts, including demographics (Part I), questionnaire items (Part II) and a box for free writing (Part III). Part II was divided into two sections with different questionnaire items. One section contains 18 items for ChatGPT users and the other one contains 19 items for ChatGPT non-users in the given class. In Part III, all the participants were welcomed to write down any ideas or suggestions associated with the use of ChatGPT in class. However, no qualitative data were collected from Part III because none of the participants wrote down anything.

With the use of SPSS StatisticsV19.0, the Cronbach's Alpha value 0.920 of the 18-item questionnaire for ChatGPT users (n=41) exceeds the threshold of 0.7 (Becker, 2000), so that its reliability is satisfactory to a very high degree. On the other hand, the Cronbach's Alpha value 0.662 of the 19-item questionnaire for ChatGPT non-users (n=11) fails to reach the threshold of 0.7 (Becker, 2000), so its reliability is not satisfactory. After deleting item 1, “I don’t know the existence of ChatGPT,” the Cronbach's Alpha value 0.710 of the 18-item questionnaire for ChatGPT non-users (n=11), exceeding the threshold of 0.7 (Becker, 2000), can indicate that its reliability is satisfactory.

Results and Discussion

The current study was aimed to explore the voices of ChatGPT users and non-users about the use of ChatGPT in an English class. The results of the quantitative data through the utilization of Excel were analyzed from three aspects: entire participants, ChatGPT users (n=41), and ChatGPT non-users (n=11).

Entire Participants

As shown in Table 1, 98.1% of the participants indicated their willingness to use ChatGPT in future classes. Interestingly, one female participant (1.9%) reported that she would not continue using the tool. However, due to a lack of relevant data, no explanation could be determined for her decision, as she remained an unidentified freshman.

All ChatGPT users (n = 41) reported that the tool was easy to use (see item 2 in Table 3), a view shared by all non-users (n = 11) as well (see item 2 in Table 4). Therefore, across the entire sample of 52 AFL freshmen, there was unanimous agreement regarding the ease of use of ChatGPT. These findings align with those of Ngo (2023), who noted that Vietnamese college students held a generally positive attitude toward ChatGPT, particularly in relation to its user-friendliness.

Regarding the perceived impact on independent thinking, only 51.22% of ChatGPT users believed that the tool could enhance their independent thinking skills (item 8, Table 3). Conversely, 45.45% of non-users expressed concern that the tool might weaken such skills (item 5, Table 4). These findings correspond with those of Farrokhnia et al. (2023), who highlighted the potential drawback of AI tools in diminishing higher-order cognitive engagement.

Similarly, Ye (2023) reported that some CYCU students were concerned about the risk of over-reliance on ChatGPT potentially impairing their independent learning and critical thinking. These results underscore the nuanced and multifaceted influence of AI tools on students' autonomous learning abilities.

On another note, all 11 ChatGPT non-users agreed that the tool could help generate new or diverse ideas for completing assignments (item 3, Table 4). This view was shared by 90.24% of ChatGPT users (item 6, Table 3), suggesting a broad consensus on the tool's capacity to support idea generation, albeit with a slight difference in degree between users and non-users.

ChatGPT Users

In this study, ChatGPT users were defined as participants who utilized ChatGPT within the given course (n = 41). As shown in Table 1, 78.8% of all participants reported using ChatGPT in the course, a finding that aligns with Ye's (2023) report indicating that 66% of CYCU students had prior experience using the tool. This comparison suggests a growing trend in ChatGPT adoption among university students.

The results presented in Table 3 indicate that ChatGPT users expressed a high level of satisfaction with the tool, which, in turn, reinforced their willingness to continue using it. These results support the notion that ChatGPT is an effective and valuable resource in language learning contexts. More specifically, AFL freshmen recognized the tool's usefulness across a range of dimensions, serving as a composite indicator of its success in meeting users' expectations.

Table 3 highlights several key features of ChatGPT that contributed to its favorable reception. Participants found the tool not only easy to use but also capable of providing quick access to information, improving work efficiency, stimulating creative thinking, and enhancing organizational abilities. These features contributed to an overall high satisfaction rating and demonstrate the tool's broad applicability and appeal in educational settings, echoing its growing global utility.

Several specific reasons were identified for students' use of ChatGPT in the course. All 41 users (100%) reported that the tool was easy to use (item 2). Furthermore, 95.12% indicated that it helped them complete assignments more efficiently (item 3), and an equal percentage believed the tool could provide information and answers promptly (item 4). Additionally, 90.24% agreed that ChatGPT could generate a variety of ideas (item 6), indicating that the tool supported users in discovering perspectives or concepts they might not have considered otherwise. This suggests that ChatGPT can serve as a thought-provoking aid that broadens users' knowledge and stimulates intellectual engagement.

Moreover, 87.80% of participants expressed overall satisfaction with ChatGPT's functionalities (item 1), while 85.37% believed that it could enhance their organizational skills (item 11). However, only 14.63% indicated a willingness to pay for a premium version of the tool (item 18). Nevertheless, this figure may increase in the future as students begin to recognize the necessity of such tools in their academic or professional pursuits.

Table 3. Results of the Questionnaire – 41 ChatGPT Users

Rank	Item: The reasons why I use ChatGPT in the course because	St. A %	A %	So. A %	Total	Mean
1	2. it is easy to use	24.39 %	46.34 %	29.27 %	100 %	4.95
2	4. it helps me do homework more efficiently	29.27 %	31.71 %	34.15 %	95.12 %	4.85
3	3. it can provide information and answers fast	24.39 %	39.02 %	31.71 %	95.12 %	4.83
4	6. it can generate different ideas	17.07 %	12.20 %	60.98 %	90.24 %	4.34
5	1. in general, I am satisfied with its functionality	17.07 %	41.46 %	29.27 %	87.80 %	4.61
6	11. using it will improve my organizational skills	7.32 %	26.83 %	51.22 %	85.37 %	4.22
7	10. using it will boost my information assessment skills	12.20 %	19.51 %	48.78 %	80.49 %	4.20
8	12. it can answer all kinds of questions	19.51 %	24.39 %	31.71 %	75.61 %	4.24
9	9. using it will improve my information searching skills	9.76 %	31.71 %	34.15 %	75.61 %	4.22
10	7. the answers from it are more creative than mine	7.32 %	19.51 %	48.78 %	75.61 %	4.05
11	16. I can use it to verify my answers	9.76 %	21.95 %	41.46 %	73.17 %	4.07
12	13. its functionality is comprehensive (e.g. presentation layout and translation)	7.32 %	19.51 %	43.90 %	70.73 %	3.98
13	14. its translations are better than those from other AI's	7.32 %	26.83 %	34.15 %	68.29 %	3.95
14	5. it can categorize information from the internet so that I don't need to search other websites	7.32 %	12.20 %	43.90 %	63.41 %	3.78

15	17. its error rate is extremely low when I use it to do my homework	4.88 %	12.20 %	41.46 %	58.54 %	3.68
16	15. it can replace dictionaries	9.76 %	17.07 %	29.27 %	56.10 %	3.61
17	8. using it will enhance my independent thinking skills	4.88 %	12.20 %	34.15 %	51.22 %	3.59
18	18. I am willing to pay for using a higher version of ChatGPT	0.00 %	7.32 %	7.32 %	14.63 %	2.37

Note. St. A: Strongly Agree (6); A: Agree (5); So. A: Somewhat Agree (4); all percentages and means were rounded up from second decimal point.

Regarding the speed of information access, Ye's research (2023) reported that some CYCU students believed ChatGPT facilitated rapid comprehension of key summaries. This finding aligns with those of Farrokhnia et al. (2023) and Ngo (2023), who respectively noted that ChatGPT could provide immediate answers and significantly reduce the time needed to obtain information. Similarly, in the present study, 95.12% of ChatGPT users agreed that the tool could quickly provide relevant information and answers (item 3), reinforcing these earlier findings.

In terms of efficiency, Ye (2023) also found that some students considered ChatGPT to outperform Google Translate in translation tasks. This perception is reflected in the current study, where 68.29% of ChatGPT users agreed that its translations were superior to those of other AI tools (item 14). Moreover, 90.24% of users agreed that ChatGPT could generate diverse ideas (item 6), while 75.61% indicated that the tool was capable of answering a wide range of questions (item 12). These findings echo Ngo's (2023) results, which highlighted ChatGPT's usefulness in idea generation for writing tasks and its ability to provide information across various domains.

Taken together, these studies and the current findings suggest a shared consensus regarding ChatGPT's contribution to enhancing learning efficiency across multiple educational functions.

ChatGPT Non-Users

In this study, *ChatGPT non-users* were defined as participants who did not utilize ChatGPT during the *Tour Manager and Tour Guide English* course (n=11). Table 4 presents the reasons reported by these 11 AFL freshmen for not using the tool. The five most frequently cited reasons were as follows: (a) 81.82% of participants noted that ChatGPT often provided inconsistent responses to the same questions (item 13); (b) an equal percentage (81.82%) found it burdensome to reorganize and interpret the tool's answers into a standardized format (item 18); (c) 63.64% expressed concerns about the accuracy of ChatGPT's data, believing it was not entirely reliable (item 11); (d) 54.55% preferred interacting with real people over relying on the tool when working in teams (item 19); and (e) 54.55% viewed the use of ChatGPT to complete assignments as a potential form of plagiarism (item 17).

Table 4. Results of the Questionnaire – 11 ChatGPT Non-Users

Rank	Item: The reasons why I didn't use ChatGPT in the course because___	*St. A* %	*A* %	*So. A* %	Total	Mean
1	13. it shows different answers to the same questions.	18.18 %	18.18 %	45.45 %	81.82%	4.27
2	18. the answers from the tool are standard, so they need organizing	18.18 %	9.09 %	54.55 %	81.82%	4.27
3	11. the data from the tool is not 100% correct	9.09 %	18.18 %	36.36 %	63.64%	3.82
4	19. I prefer to interact with people rather than with the tool when doing group work	9.09 %	27.27 %	18.18 %	54.55%	4.00
5	17. using it to complete homework would be considered plagiarism	0.00 %	9.09 %	45.45 %	54.55%	3.36
6	5. using it will weaken my independent thinking skills	0.00 %	27.27 %	18.18 %	45.45%	3.45
7	12. using it makes me feel like a robot receiving instructions	0.00 %	9.09 %	36.36 %	45.45%	3.27
8	7. using it will weaken my information assessment skills	0.00 %	18.18 %	18.18 %	36.36%	3.27
9	16. using it will get caught by teachers	18.18 %	0.00 %	18.18 %	36.36%	3.18
10	4. the answers from my own are more creative than those from the tool	9.09 %	0.00 %	18.18 %	27.27%	3.18
11	6. using it will weaken my information searching skills	0.00 %	18.18 %	9.09 %	27.27%	3.09
12	9. the translations from the tool are worse than those from other AIs	0.00 %	9.09 %	18.18 %	27.27%	3.00
13	14. the answers from the tool are often repetitive	0.00 %	18.18 %	9.09 %	27.27%	3.27
14	8. using it will weaken my organizational skills	0.00 %	0.00 %	18.18 %	18.18%	2.82
15	10. paper dictionaries are easier to use than the tool	0.00 %	9.09 %	0.00 %	9.09 %	2.45
16	15. it could become a means of cheating	0.00 %	0.00 %	9.09 %	9.09 %	2.18
17	2. it is not easy to use	0.00 %	0.00 %	0.00 %	0.00 %	1.73
18	3. it cannot inspire different thoughts	0.00 %	0.00 %	0.00 %	0.00 %	2.27

Note. St. A: Strongly Agree (6); A: Agree (5); So. A: Somewhat Agree (4). All percentages and means were rounded up from second decimal point.

Comparatively, 54.55% of ChatGPT non-users considered the use of the tool for completing homework or assignments to be a form of plagiarism (item 17). This finding aligns with the research of Farrokhnia et al. (2023) and Ngo (2023), both of whom underscored the significance of upholding academic ethics, integrity, and the avoidance of plagiarism in educational contexts. These results highlight the ongoing importance placed on ethical standards in academic work.

Interestingly, however, only 9.09% of non-users reported that they refrained from using ChatGPT due to concerns that it might constitute a form of cheating (item 15), suggesting a nuanced distinction among

students between plagiarism and academic dishonesty.

Conclusion

The purpose of the present study was to examine AFL freshmen's attitudes toward the use of ChatGPT in the *Tour Manager and Tour Guide English* course. The findings suggest that ChatGPT not only enhances learning efficiency and quality but also fosters students' interest and motivation in learning. These results are consistent with the findings of Jauhiainen and Guerra (2023) and Aydın Yıldız (2023), who similarly reported positive educational impacts of ChatGPT use. Overall, both ChatGPT users (n = 41) and non-users (n = 11) in this study agreed that the tool was easy to use. Additionally, 98.1% of all the 52 participants indicated a willingness to use ChatGPT in future learning contexts.

More specifically, ChatGPT users in the course primarily utilized the tool because it enabled them to complete assignments more efficiently, provided rapid access to information and answers, and facilitated the generation of diverse ideas, among other benefits. Overall, users expressed high levels of satisfaction with ChatGPT, which in turn strengthened their willingness to continue using the tool. These findings further support the tool's potential as a valuable resource in language learning contexts.

In contrast, non-users chose not to engage with ChatGPT in class primarily due to a preference for independent learning, concerns about becoming overly reliant on the tool, and skepticism regarding the reliability and accuracy of the content it generated. These attitudes reflect a cautious approach toward integrating AI technologies in academic environments.

Educational Implication

The integration of ChatGPT into language teaching and learning is both valuable and worthy of further support. Findings from the present study revealed that 98.1% of participants (N=52) expressed their intention to use ChatGPT in future courses, with only one respondent indicating otherwise. This overwhelming acceptance underscores the growing trend of AI-assisted tools in education. Although some educators have opted to prohibit the use of ChatGPT in their classrooms, such restrictions are largely ineffective, as teachers cannot continuously monitor students' learning behaviors (Kao, 2023). Banning access during school hours does not prevent students from utilizing the tool outside of class, such as at home (Ali et al., 2023; Lee, 2023). Therefore, the priority should not be prohibition but rather the development of clear, pedagogically sound guidelines for its use.

These guidelines should aim to instruct students on how to use ChatGPT responsibly and effectively to support their learning (AlAfnan et al., 2023; Fuchs, 2023; Ho, 2024; Kao, 2023; Lee, 2023; Mohammed et al., 2023), while also fostering critical thinking skills to help them identify inaccuracies and potential misinformation (Farrokhnia et al., 2023; Kao, 2023). Moreover, such

frameworks can enhance students' understanding of academic integrity and raise awareness of unethical practices, such as plagiarism (Farrokhnia et al., 2023; Fuchs & Aguilos, 2023; Mohammed et al., 2023; Ngo, 2023). While ChatGPT holds potential to enrich language instruction, successful integration into the classroom requires that teachers themselves develop proficiency with the tool (Montenegro-Rueda et al., 2023).

Limitations

Several limitations can be elicited form the current study. The study specifically targeted AFL freshmen enrolled in the *Tour Manager and Tour Guide English* course at a national technical university in Mid-Southern Taiwan. Therefore, the conclusions drawn from the current study may not be generalized to other academic disciplines, such as English Writing classes, or to students in different majors or educational institutions.

It is strongly important to recognize that the scope of this study was confined to a specific course within a particular national technical university context in Taiwan, and thus caution should be exercised when applying these findings to broader educational settings or diverse student populations.

Future Studies

In the current study, the basic profiles show a significant gender imbalance, with 47 female participants (90.4%) and 5 male participants (9.6%). Regarding TOEIC scores, only 5 participants (9.6%) scored 700 or higher, while 34 participants (65.4%) scored below 700, and 13 participants (25.0%) had not taken the TOEIC test. Thus, in future studies, the researchers and other interested researchers can focus on balanced gender proportion and English proficiency proportion.

Furthermore, future research studies could explore such issues as different educational contexts and student populations to enrich research, theory, and practice of the relevant field, especially language teaching and learning.

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Exploring an AR System for Women's Hairstyling Certification: Technology Acceptance Model Validation

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This study explores how Augmented Reality (AR) technology can be integrated into the practical training framework for Taiwan's Class C Women's Hairstyling Technical Skills Certification. Enhancing practitioners' skills through certification has become essential with the increasing demand for professionalism in hairstyling. The Taiwanese Ministry of Labor has established regulations to standardize the certification process, including theoretical and practical assessments. Our research focuses on creating an AR-based instructional system that enables real-time demonstrations of hairstyling techniques, allowing students to engage in self-directed learning. This innovative system provides clear technical explanations and allows students to practice repeatedly without the constant need for teacher supervision. By utilizing AR, students can access on-demand learning tailored to their individual needs, overcoming the traditional time and location constraints. This study employs the Technology Acceptance Model (TAM) to evaluate students' perceptions and intentions regarding using the AR instructional system. The findings indicate that AR significantly enhances students' understanding and operational skills in hairstyling techniques, ultimately improving their readiness for certification exams. This research contributes to the existing literature by demonstrating how Augmented Reality (AR) can transform vocational training in hairstyling, creating a more engaging and effective learning environment while improving students' self-directed learning abilities.

Keywords - Augmented Reality (AR), Technology Acceptance Model (TAM), Vocational Training, Behavioral Intention, Technical Skills Certification

Relevance to Design Practice - This study offers design practitioners an evidence-based AR instructional framework that supports flexible, self-directed skills training, which can inspire innovative educational tools for vocational certification and

professional upskilling.

Introduction

Augmented Reality (AR) technology blends virtual elements with the real world, creating compelling experiences by overlaying digital content onto our physical surroundings. Accessible through smartphones, tablets, and specialized devices, AR facilitates immediate interaction with users. AR has rapidly gained popularity across various sectors, including advertising, entertainment, and education, transforming lifestyles and creating new opportunities, particularly in education and business (Mendoza-Ramírez et al., 2023).

Advancements in hairstyling techniques and an increasing demand for professionalism have made it vital to enhance the skills of practitioners in the hairstyling industry. Obtaining certification is essential, as it formally recognizes professional capabilities. In Taiwan, the Ministry of Labor has established regulations for Technical Skills Certification in Women's Hairstyling to elevate industry standards and protect consumer rights. Vocational high schools and universities actively encourage students to pursue certification exams, thereby enhancing their technical expertise and competitiveness in the job market after graduation. Unlike general certification exams, technical certifications require extensive hands-on practice, depending on both teacher guidance and students' dedication to self-directed practice.

This study explores the practical exam requirements for the Women's Hairstyling Class C Technical Skills Certification established by Taiwan's Ministry of Labor. Its objective is to develop an AR instructional system that enhances practical training for this certification. The AR system enables students to participate in real-time demonstrations of hairstyling techniques, offering clear explanations without the need for teacher supervision. This innovative approach allows students to repeatedly review key techniques, thereby deepening their understanding and improving their operational proficiency. By facilitating on-demand and personalized practice, the system supports flexible learning that is not constrained by time or location. This study also employs the Technology Acceptance Model (TAM) to evaluate students' intentions to use and their perceptions of this pioneering AR instructional system.

Literature review

Hairdressing certification

Implementing a national technical certification system has significantly enhanced professional standards in the hairstyling industry. Taiwan's Ministry of Labor introduced the Skills Certification for Women's Hairstylists to assess relevant skills and address the industry's evolving needs. This program offers two levels of certification: Class B for skilled technicians and Class C for general technicians. Candidates must pass both a written exam and a practical test to achieve certification at either level.

Application of augmented reality in education

Augmented Reality (AR) enhances traditional learning by integrating digital information into the real-world environment, creating a more immersive experience for students (Qiu et al., 2023). This technology helps learners access resources that clarify complex concepts and capture their attention (Sırakaya, 2022). AR promotes interaction (Godwin-Jones, 2016) and boosts motivation and engagement, improving knowledge and skills (Topu et al., 2023).

In education, AR can improve learning efficiency, interactivity, and collaboration. For example, AR can simulate chemical reactions in chemistry classes for deeper understanding (Ripsam & Nerdel, 2022). In biology, students can interact with dinosaur fossils, and in history, they can engage with ancient artifacts (Ibharim et al., 2021). AR also personalizes learning by adapting content to meet individual student needs, such as customized vocabulary tests in English classes (Mamani-Calapuja, 2023). It provides educational resources to remote areas, allowing students to explore global art and music (Ghulamani & Zareen, 2018). Furthermore, AR fosters collaboration by enabling teamwork in virtual environments (Chan et al., 2022).

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was introduced by Davis (1986) to explain and predict how individuals accept information technology. TAM is based on the Theory of Reasoned Action (TRA), developed by Ajzen & Fishbein (1980). TRA suggests that behavioral intention is the primary factor influencing an individual's behavior. According to TRA, behavioral intention is determined by both attitude and subjective norms.

The Technology Acceptance Model (TAM) includes four key components that are commonly used to predict the factors influencing both organizational and individual adoption of specific technologies (Rauschnabel & Ro, 2016): Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude (ATT), and Behavioral Intention (BI).

1. Perceived Usefulness (PU) refers to the extent to which individuals believe that using specific technology will enhance their performance (Davis et al., 1989).
2. Perceived Ease of Use (PEOU) reflects how effortless and straightforward individuals perceive the technology to be (Davis et al., 1989).
3. Attitude (ATT) describes an individual's evaluation of the desirability of using a particular technology (Fishbein & Ajzen, 1975).
4. Behavioral Intention (BI) measures the likelihood that an individual will adopt the technology (Fishbein & Ajzen, 1975).

TAM posits that perceived usefulness and ease of use positively influence individuals' attitudes toward technology. These attitudes, in turn, have a favorable impact on behavioral intention. Consequently, perceived usefulness and perceived ease of use directly and positively affect people's acceptance of information technology. This model has been widely utilized in the field of information technology, aiding researchers in understanding how individuals adopt various technologies (Martínez et al., 2014).

Effect of Perceived Ease of Use on Perceived Usefulness

When users find technology easy to learn and use, they are more likely to accept it and view it as beneficial for their personal or professional tasks (Davis, 1989). The simple operation helps users grasp the technology's functionality and recognize its value. This promotes widespread adoption of the technology and builds users' acceptance and trust in it (Ly & Ly, 2024).

Research on the use of augmented reality (AR) technologies shows that when users find AR applications easy to navigate, they are more likely to appreciate the convenience and assistance these technologies provide while shopping. This positive experience enhances their perception of the technology's usefulness (Baek et al., 2018).

Similarly, studies on virtual fitting rooms conducted by Sunana et al. (2023) indicate that consumers' perceptions of ease of use significantly enhance their evaluations of the technology's usefulness. Based on this understanding, we can propose the following hypothesis:

H1: Perceived ease of use has a significant positive effect on perceived usefulness.

Effect of Perceived Ease of Use on Attitude

When users perceive a technology or system as easy to use and requiring minimal effort, they are more likely to

develop a positive attitude toward it (Davis, 1989). In the context of augmented reality (AR) applications, users' perceptions of ease of use directly influence their attitudes, which in turn affect their behavioral intentions (Venkatesh & Bala, 2008). Pantano et al. (2017) emphasized that when AR systems, such as virtual fitting room features, provide simple and intuitive user experiences, users are more likely to accept the technology and develop more favorable attitudes toward it. Based on this understanding, we can propose the following hypothesis:

H2: Perceived ease of use has a significant positive effect on attitude.

Effect of Perceived Ease of Use on Behavioral Intention

When users find a technology that is easy to use and requires minimal effort, they are more likely to adopt it and develop positive intentions towards its use. This perceived ease of use reduces the challenges related to learning and adapting to technology, which in turn enhances users' acceptance and willingness to engage with it. Research has shown that perceived ease of use has a positive impact on users' behavioral intentions. When individuals discover that a technology is simple to learn and operate, they are more inclined to use it in the long run, which contributes to its widespread adoption and application (Dwivedi et al., 2019). Based on this understanding, the following hypothesis can be proposed:

H3: Perceived ease of use has a significant positive effect on behavioral intention.

Effect of Perceived Usefulness on Attitude

Perceived usefulness refers to users' belief that technology can enhance their work or daily tasks, which directly influences their attitude toward that technology. When users believe a system significantly improves their efficiency, they tend to develop a more positive attitude toward it. Delone and McLean (2003) showed that perceived usefulness is strongly correlated with behavioral intention. Additionally, when users find technology easy to learn and use, they are more likely to adopt it over the long term, promoting broader acceptance and application (Dwivedi et al., 2019).

Molefi et al. (2024) discovered that perceived usefulness has a significant positive impact on teachers' attitudes toward adopting artificial intelligence (AI) technologies in education. Teachers who believe that AI can improve their teaching effectiveness are more likely to have favorable attitudes toward these technologies. Similarly, Recalde et al. (2024) found that perceived usefulness is one of the strongest predictors of consumer attitudes regarding augmented reality (AR) applications in shopping.

Perceived usefulness is widely acknowledged as a key factor that affects users' attitudes toward technology. It plays a significant role in shaping their trust and positive evaluations of the system (Venkatesh & Bala, 2008). Due to its established positive influence on user attitudes, the following hypothesis is proposed:

H4: Perceived usefulness has a significant positive effect on attitude.

Effect of Perceived Usefulness on Behavioral Intention

When users feel that technology enhances their work efficiency and effectiveness, they are more likely to adopt and use it (Venkatesh & Davis, 2000). For example, when consumers believe that augmented reality (AR) technology improves their shopping experience and offers practical features, they are more inclined to engage with it. This indicates that perceived usefulness is not only a key factor influencing technology acceptance but also an essential motivator driving consumer behavior (Pantano et al., 2017).

Bastari et al. (2020) conducted a study on the digitalization of banking in Indonesia and discovered that perceived usefulness has a direct and positive effect on employees' intentions to use digital platforms. This improvement in perceived usefulness enhances work efficiency and task performance. Their findings support the positive relationship between perceived usefulness and behavioral intention. Based on this, we propose the following hypothesis:

H5: Perceived usefulness has a significant positive effect on behavioral intention.

Effect of Attitude on Behavioral Intention

Attitude plays a crucial role in shaping behavioral intention (Fishbein & Ajzen, 1975). A more positive attitude towards technology is associated with a stronger intention to use it, reflecting a higher willingness to continue its use (Venkatesh et al., 2003). Additionally, the Theory of Planned Behavior (TPB) identifies attitude as a key predictor of behavioral intention (Ajzen, 1991).

In adopting new technologies, there is a significant positive relationship between attitude and purchase intention (Yadav & Pathak, 2017). Specifically, in augmented reality (AR) applications, users with a more favorable attitude toward technology demonstrate stronger behavioral intentions (Pantano et al., 2017). Based on this understanding, we propose the following hypothesis:

H6: Attitude has a significant positive effect on behavioral intention.

Mediating Variable: Perceived Usefulness

The perceived ease of use significantly

influences individuals' attitudes toward technology, while perceived usefulness further affects their intentions to use it. Both factors-perceived ease of use and perceived usefulness are crucial in shaping individuals' attitudes and adoption behaviors. When technology is perceived as easy to use, it enhances users' trust and familiarity, which, in turn, strengthens their perception of its usefulness. This positive perception influences their attitudes and behavioral intentions (Venkatesh & Davis, 2000). As a result, when users find technology user-friendly, they are more likely to it as valuable or beneficial, leading to a more positive attitude toward it.

Alyoussef (2022) demonstrated that perceived usefulness acts as a mediating variable between perceived ease of use and attitude, playing a crucial role in influencing learners' acceptance of flipped classrooms. Therefore, the following hypothesis is proposed:

H7: Perceived usefulness mediates the relationship between perceived ease of use and attitude.

When users feel confident in using technology and view it as helpful for achieving their goals, this perception of ease of use directly influences their perception of usefulness. As a result, their intention to use technology strengthens (Ly & Ly, 2024). In research on virtual reality applications in tourism, tourists who find the technology easy to operate are more likely to recognize its benefits, which increases their likelihood of adopting it (Osafo et al., 2021). Additionally, perceived usefulness has been shown to mediate the relationship between perceived ease of use and behavioral intention. Therefore, the following hypothesis is proposed:

H8: Perceived usefulness mediates the relationship between perceived ease of use and behavioral intention.

Mediating Variable: Attitude

When users find a technology that is easy to use, they are more likely to develop positive attitudes toward it, enhancing their intention to use it (Venkatesh & Davis, 2000). In this context, attitude is a mediating variable between perceived ease of use and behavioral intention. Schiopu et al. (2022) emphasized that in specific situations, intentions to use tourism-related virtual reality (VR) are influenced by perceived ease of use, with attitude playing a crucial mediating role in this relationship.

H9: Attitude mediates the relationship between perceived ease of use and behavioral intention.

When users recognize technology as useful and believe it can enhance their efficiency, they are more likely to develop a positive attitude toward it. This favorable attitude, in turn, improves their intention to use technology (Venkatesh & Davis, 2000). Research indicates that

when teachers view augmented reality (AR) technology as beneficial for teaching, they cultivate a positive attitude toward it, increasing their intention to incorporate AR technology in their teaching practices (Molefi et al., 2024). This positive attitude is a key mediator between perceived usefulness and behavioral intention.

H10: Attitude mediates the relationship between perceived usefulness and behavioral intention.

Figure 1 summarizes all hypotheses within the study's resulting conceptual framework.

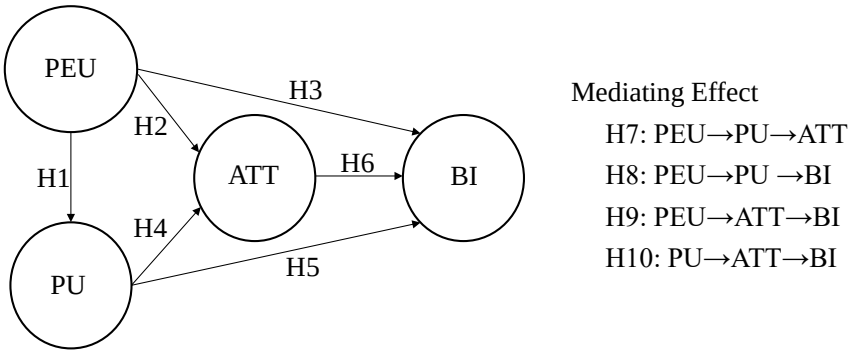

Figure 1. Conceptual framework.

Method

Development of an Augmented Reality-Assisted Hairdressing Teaching System

This study presents the development of augmented reality (AR) software designed for hairdressing training, based on the twelve practical skill test items outlined by the Ministry of Labor's Workforce Development Agency for the "Level C Female Hairdressing Technician" certification. The software utilizes the MAKAR online platform for AR editing.

The development process includes the creation of recognition markers and corresponding AR instructional videos. Each test item is divided into distinct learning modules, each assigned a unique recognition marker and instructional video. Learners can scan the relevant recognition markers using their mobile devices, granting them immediate access to the corresponding instructional videos and thereby promoting an efficient and interactive learning experience. A comprehensive overview of the recognition markers and their associated AR instructional videos for the 12 test item learning modules is available in Appendix 1. For instance, the "Standard Cold Perm" test item is broken down into five modules: A, B, C, D, and E (Figure 2). Each module has its specific

identification marker (Marker A, B, C, D, and E). When users scan a particular marker, they can view the associated augmented reality instructional video (Video A, B, C, D, and E).

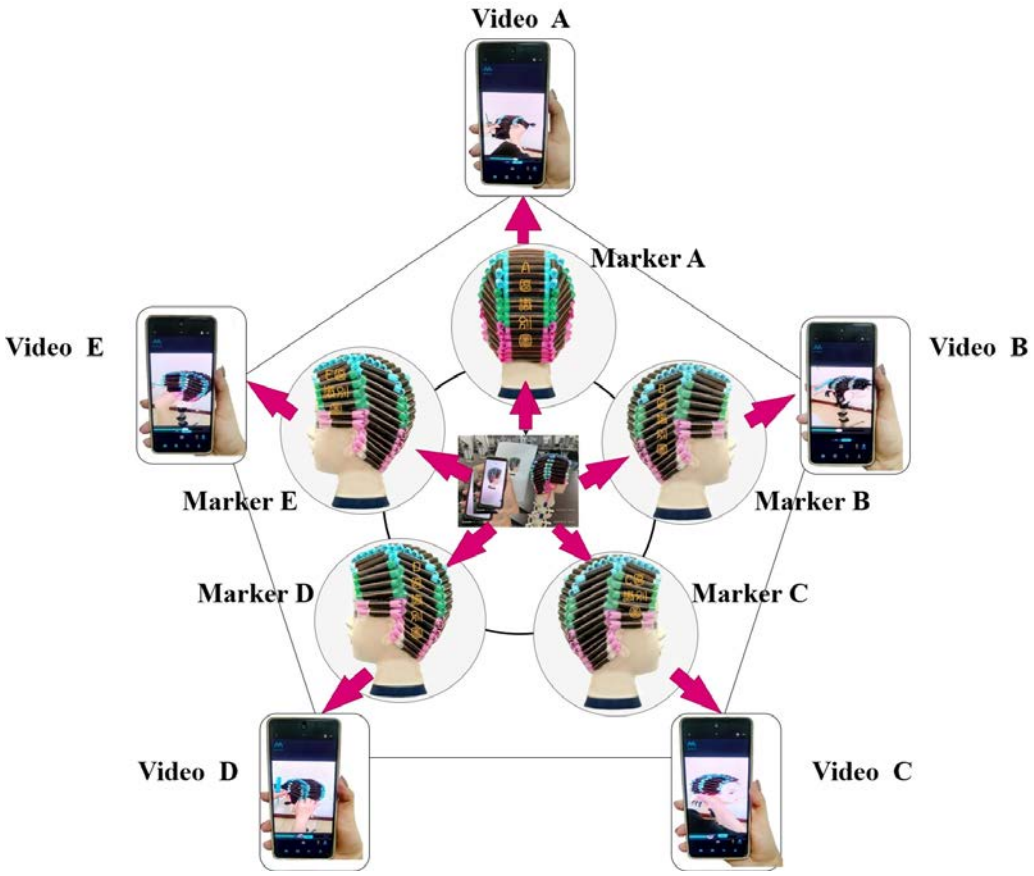

Figure 2. An example of an AR-assisted hairdressing system is the "Standard Cold Perm" module, which is divided into five distinct regions: A, B, D, and E. Learners can use their mobile devices to scan the corresponding recognition markers (Marker A to E) to instantly access augmented reality instructional videos.

Qualitative Research

This study utilized the Partial Least Squares Structural Equation Modeling (PLS-SEM) method to investigate the effects of a designed augmented reality (AR) instructional support system on users' behavioral intentions. The variables examined included perceived ease of use, perceived usefulness, and attitude. The participants in the study were college and high school students preparing for the Level C hairdressing certification exam.

Before the participants filled out the formal questionnaire, the research team either visited classrooms or offered individual explanations on how to use the

AR instructional support system. After five weeks of using the system, the participants completed questionnaires and feedback forms to share their experiences and attitudes toward it.

The items in the questionnaire were adapted from relevant literature (Table 1). These items include perceived usefulness (Davis, 1989; Cabero-Almenara et al., 2019), perceived ease of use (Davis et al., 1989; Venkatesh, 2000, three items), attitude toward usage (Fishbein & Ajzen, 1975), and behavioral intention to use (Fishbein & Ajzen, 1975). A 5-point Likert scale was used for responses.

Table 1. Constructs and questionnaire items

Construct	*Item*
Perceived Ease of Use	
PEU1	Using this AR system will enhance my learning for the hairdressing certification.
PEU2	Using this AR system will help me understand certain technical concepts.
PEU3	The AR system will improve my skills while learning for the hairdressing certification.
PEU4	The application of AR in learning for the hairdressing certification is very useful.
Perceived Usefulness	
PU1	I find this AR system very easy to use.
PU2	Learning how to use this AR system is not a problem for me.
PU3	Learning how to use the AR system is clear and easy to understand.
Attitude	
ATT1	Using this AR system makes learning more enjoyable.
ATT2	I do not feel bored when using this AR system.
ATT3	I believe that using an AR system for learning hairdressing certification is a good idea.
Behavioral Intention to Use	
BI1	I am willing to use an AR system in the future if given the opportunity.
BI2	I am willing to use an AR system to learn other subjects.

The questionnaire data were analyzed using SmartPLS 4.0. A total of 328 questionnaires were collected, 286 of which were deemed valid, resulting in a response rate of 87.19%. Among the respondents, there were 58 university students (17.68%) and 228 high school students (82.32%). Most of the respondents were female, comprising 274 individuals, which accounts for 95.80% of the total. In Taiwan, most students enrolled in hairdressing-related programs earn a C-level certification during high school, and the vast majority of these students are female.

Results and Discussion

Measurement model assessment

This study utilized Partial Least Squares Structural Equation Modeling (PLS-SEM) to validate the proposed model, ensuring its reliability and validity. The goodness of fit for the measurement model was evaluated using several assessment indices. Specifically, the evaluation of the measurement model included outer loadings, reliability tests,

convergent validity, and discriminant validity.

As shown in Table 2, all factor loadings ranged from 0.877 to 0.972, which exceeds the threshold value of 0.7. The composite reliability (CR) values fell between 0.926 and 0.946, while Cronbach's α coefficients ranged from 0.880 to 0.944; both of these measures exceeded the minimum threshold of 0.7. Additionally, the average variance extracted (AVE) ranged from 0.807 to 0.942, surpassing the benchmark of 0.5. These results indicate that all indices met the required thresholds, demonstrating that the reliability and convergent validity of the individual items are at an acceptable level (Hair et al., 2012; Hair et al., 2017).

Table 2. Results of factor loadings, composite reliability, cronbach's α, and AVE

Construct	*Items*	*Factor loading*	*α*	*CR*	*AVE*
PEU	PEU1	0.921	0.915	0.941	0.854
	PEU2	0.922			
	PEU3	0.929			
PU	PU1	0.937	0.924	0.936	0.856
	PU2	0.920			
	PU3	0.931			
	PU4	0.913			
ATT	ATT1	0.927	0.880	0.926	0.807
	ATT2	0.89			
	ATT3	0.877			
BI	BI1	0.969	0.918	0.927	0.942
	BI2	0.972			

Discriminate validity assesses whether constructions are distinct and do not exhibit excessive correlation with other constructions within the same model. As shown in Table 3, the factor loadings for all items are greater than their cross-loadings, which confirms the presence of discriminant validity. Additionally, we validated discriminant validity by calculating the square root of the Average Variance Extracted (AVE) and comparing it with the correlations between the constructs. The Fornell-Larcker criterion indicates that the square root of the AVE for each construct exceeds its correlations with other constructs, demonstrating adequate discriminant validity.

Table 3. Results of cross-loadings

	PEU	*PU*	*ATT*	*BI*
PEU1	0.921	0.815	0.803	0.800
PEU2	0.922	0.719	0.803	0.804
PEU3	0.929	0.808	0.783	0.739
PU1	0.792	0.937	0.763	0.725
PU2	0.757	0.92	0.772	0.705
PU3	0.786	0.931	0.774	0.658
PU4	0.798	0.913	0.869	0.767

ATT1	0.791	0.746	0.927	0.755
ATT2	0.785	0.756	0.89	0.677
ATT3	0.778	0.791	0.877	0.858
BI1	0.709	0.794	0.8	0.969
BI2	0.785	0.817	0.857	0.972

Table 4. Results of Fornell-Larcker

	PEU	***PU***	***ATT***	***BI***
PEU	0.924			
PU	0.846	0.925		
ATT	0.873	0.852	0.898	
BI	0.771	0.83	0.855	0.971

Structural Model Evaluation

Table 4 shows the assessment of the proposed measurement model and hypothesis testing performed using Smart PLS 4 software. Table 5 displays the results of the direct relationships in the structural model.

Table 5. Path analysis of the conceptual model

Hypothesis	Path	Coefficient (β)	p-value	Result
H1	PEU → PU	0.846	0.000	Supported
H2	PEU → ATT	0.536	0.000	Supported
H3	PEU → BI	-0.068	0.744	Not Supported
H4	PU → ATT	0.398	0.001	Supported
H5	PU → BI	0.396	0.002	Supported
H6	ATT → BI	0.577	0.001	Supported

The evaluation results show that the model effectively explains and predicts the variance in endogenous variables that are influenced by exogenous variables. To prevent multicollinearity from significantly affecting the estimation of the structural model, it is generally recommended that the variance inflation factor (VIF) values for predictor variables remain below 5 (Hair et al., 2011). As presented in Table 6, all VIF values are below 5, confirming that there are no multicollinearity issues.

Table 6. Results of VIF

PEU		***PU***		***ATT***		***BI***	
Item	VIF	Item	VIF	Item	VIF	Item	VIF
PEU1	3.097	PU1	4.699	ATT1	3.364	BI1	4.569
PEU2	3.283	PU2	4.038	ATT2	2.746	BI2	4.569
PEU3	3.181	PU3	4.430	ATT3	2.070		
		PU4	3.775				

The R^2 value indicates how well the relevant exogenous variables collectively explain the variance in an endogenous variable. It reflects the overall impact of exogenous latent variables on endogenous latent variables. According to Chin (1998), R^2 values of 0.60, 0.33, and 0.19 are classified as indicating high, moderate, and low explanatory power, respectively. In this study, the R^2 value for the endogenous variable "Perceived Usefulness" is 0.716, for "Attitude" it is 0.808, and for "Behavioral Intention," it is 0.769. These R^2 values demonstrate the high predictive capability of the structural model.

Hypothesis testing

This study utilized the bootstrapping method, using 5,000 resamples, to test the proposed hypotheses.

As presented in Table 6, all hypothesized relationships between exogenous and endogenous constructs were found to be significant, except Hypothesis H3. Specifically, Perceived Ease of Use has a significant influence on Perceived Usefulness ($\beta = 0.846$, $p = 0.000$) and also significantly impacts Attitude ($\beta = 0.536$, $p = 0.000$). However, Perceived Ease of Use does not have a meaningful effect on Behavioral Intention ($\beta = -0.068$, $p = 0.744$).

Additionally, Perceived Usefulness is shown to significantly influence Attitude ($\beta = 0.398$, $p = 0.001$) and Behavioral Intention ($\beta = 0.396$, $p = 0.002$). Furthermore, Attitude has a positive impact on Behavioral Intention ($\beta = 0.577$, $p = 0.001$). Overall, these findings confirm that most of the hypothesized relationships are statistically significant, except the effect of Perceived Ease of Use on Behavioral Intention.

Table 7. Mediating Effects Path Coefficients and Results

Path	Indirect Effect (β)	p-value	VAF	Result
PEU→PU→ATT	0.337	0.001	0.386	H7: Supported
PEU→PU →BI	0.335	0.002	1.000	H8: Supported
PEU→ATT→BI	0.309	0.003	1.000	H9: Supported
PU→ATT→BI	0.230	0.029	0.390	H10: Supported

Table 7 illustrates the mediating effects of Perceived Usefulness and Attitude. The findings confirm that all mediating effects are statistically significant.

Perceived Usefulness serves as a mediator in the relationship between Perceived Ease of Use and Attitude (H7), as well as between Perceived Ease of Use and Behavioral Intention (H8). The standardized beta values for these relationships are 0.337 ($p = 0.001$) and 0.335 ($p = 0.002$), respectively.

Attitude serves as a mediator in the relationship between Perceived Ease of Use and Behavioral Intention (H9), as well as between Perceived Usefulness and Behavioral Intention (H10). The beta values for these relationships are 0.309 ($p = 0.003$) and 0.230 ($p = 0.029$), respectively. Both mediating effects are statistically significant.

In the pathways of PEU → PU → BI and PEU → ATT → BI, the direct effect of PEU on BI is not significant. This indicates that PU and ATT play fully mediating roles. Conversely, in the pathways of PEU → PU → ATT (VAF = 0.386) and PU → ATT → BI (VAF = 0.390), the mediators (Perceived Usefulness and Attitude) function as partial mediators. These findings highlight the important roles of Perceived Usefulness and Attitude in explaining the indirect effects within the proposed model.

Discussion

Perceived Ease of Use Significantly Influences Perceived Usefulness

Perceived ease of use refers to the belief that technology is simple to operate, significantly influencing users' perceptions of its usefulness and overall value. When systems are easy to navigate, users are more inclined to believe they enhance efficiency, increasing their intention to use them.

For example, research conducted by Lu and Xu (2024) found that travelers who perceive ride-hailing services as user-friendly are more likely to believe that these services save time and improve travel efficiency, thereby enhancing their perception of the usefulness of electrified ride-hailing vehicles. A study by Acharya and Mekker (2022) on connected vehicles indicated that perceived ease of use has a substantial impact on users' perceptions of usefulness and their intentions to adopt the technology.

Students utilizing AR-assisted systems were able to conveniently review their knowledge at any time without incurring additional learning costs, which enhanced their perception of the technology's benefits. Overall, when users find technology easy to use, it fosters greater acceptance and a positive evaluation of its advantages across various applications.

Perceived Ease of Use Significantly Influences Attitude

The perceived ease of use of technology significantly alleviates users' psychological burdens and time costs during learning and operational processes. This not only encourages the adoption of new technologies but also reduces feelings of frustration. Elnadi et al. (2024) highlight that a user-friendly experience elicits positive emotional responses,

enhancing users' perceptions of the technology and fostering a more favorable attitude toward it. When technology is intuitive, users can quickly comprehend its functions and fully leverage its benefits. Positive experiences build trust and satisfaction, leading to greater recognition, acceptance, and a higher likelihood of ongoing use.

In this study, students scanned specific areas to access hairdressing tutorial videos, providing an engaging and convenient experience. This approach allowed learners to swiftly enter a learning state without restrictions of time or location, minimizing wasted effort and enhancing their positive attitudes toward the system.

Perceived Usefulness Significantly Influences Attitude

Perceived usefulness significantly influences attitudes, aligning with Expectancy-Value Theory (Atkinson, 1957), which asserts that individuals develop positive perceptions of objects they deem helpful in achieving their goals (Wan & Shen, 2015). When users recognize technology as enhancing efficiency or meeting their needs, they are more inclined to adopt favorable attitudes toward it. For example, research indicates that perceived usefulness enhances teachers' acceptance of artificial intelligence technologies (Molefi et al., 2024) and plays a critical role in fostering positive attitudes toward smartphone chatbots (Kasilingam, 2020).

In the context of augmented reality (AR) systems, their intuitive design and engaging features greatly improve users' attitudes toward learning. AR can alleviate the monotony often associated with traditional educational methods, allowing students to pinpoint weaknesses and engage in targeted reinforcement, thereby enhancing learning efficiency. Furthermore, the immediate access to instructional videos bolsters operational skills, leading to a greater appreciation for AR systems and increasingly positive attitudes toward their use in education.

Perceived Usefulness Significantly Influences Behavioral Intention

Perceived usefulness plays a pivotal role in shaping users' intentions to engage with technology. When users recognize that a technology provides practical benefits, such as cost savings and enhanced convenience, they are more likely to continue using it. For example, Lu and Xu (2024) found that travelers who acknowledged the advantages of electric ride-sharing services were more inclined to use them. Similarly, Nawi et al. (2024) discovered that users in Indonesia who viewed electronic wallets as convenient were more likely to adopt this technology.

In this study, students who

perceived the augmented reality (AR) system as effective for their learning showed a positive intention to use it and were motivated to incorporate such tools into their education.

Attitude Significantly Influences Behavioral Intention

Attitude plays a significant role in shaping behavioral intentions, as it reflects an individual's assessment of specific behaviors. This evaluation, influenced by beliefs, emotions, and past experiences, determines whether a person holds a positive or negative outlook. Individuals with positive attitudes are more inclined to act (Elnadi et al., 2024).

For example, Lu and Xu (2024) found that an individual's intention to continue using electric ride-sharing services is greatly impacted by their attitude. When travelers view these services as convenient and environmentally friendly, they develop a positive perspective, which increases the likelihood of ongoing usage and recommendations to others. Therefore, enhancing consumer attitudes is crucial for fostering behavioral change (Lu & Xu, 2024).

In this study, students who held a positive attitude toward the AR-assisted system were more likely to utilize the tool for future learning. The intuitive design of the AR system made the learning experience engaging and enjoyable, further reinforcing their intention to engage with the system and strengthening their behavioral intentions.

Perceived Ease of Use Does Not Significantly Influence Behavioral Intention

Intrinsic motivation drives individuals to engage in activities for inherent satisfaction, enjoyment, or curiosity, while extrinsic motivation is influenced by external goals or rewards, such as improving performance or saving time. Perceived usefulness, a form of extrinsic motivation, indicates the belief that technology helps users complete tasks more efficiently.

The significance of intrinsic and extrinsic motivations can vary by context. When technology is used for task completion, perceived usefulness often outweighs perceived ease of use; users prioritize efficiency over simplicity (Moon & Kim, 2001). For example, students using an AR-assisted system for learning hairdressing prioritize how well the system supports their learning goals, often investing extra time to navigate it despite potential challenges.

Even with operational difficulties, students who find the technology useful tend to maintain a positive attitude and are motivated to overcome those obstacles. Moon and Kim (2001) highlighted that in contexts where efficiency is key, perceived usefulness is

the primary factor influencing behavioral intention, while perceived ease of use becomes less significant.

The Mediating Role of Perceived Usefulness

When users find a technology easy to use, they are more likely to believe it enhances their performance, resulting in a positive attitude toward the technology. This indicates that perceived ease of use influences attitudes through perceived usefulness, serving as a crucial mediating variable.

For instance, studies on digital payment systems in Cambodia (Ly & Ly, 2024) and MOOCs (Wu & Chen, 2017) show that ease of use positively impacts behavioral intentions by enhancing perceived usefulness. Wan and Shen (2015) also highlighted this effect in urban green spaces, while Chen and Wu (2020) found similar results in educational settings.

A study by Chen et al. (2023) on public acceptance of automated vehicles in Australia revealed that perceiving the technology as easy to use increases its perceived usefulness, which positively influences adoption intentions.

Perceived usefulness is a key factor in technology adoption, affecting both user attitudes and intentions. Improving perceived ease of use and perceived usefulness can significantly enhance positive attitudes and increase the likelihood of technology adoption.

The Mediating Role of Attitude

Attitude plays a crucial mediating role between perceived ease of use, perceived usefulness, and behavioral intention. When users find technology easy to use, it fosters positive attitudes that strengthen their intention to adopt it. Similarly, perceived usefulness enhances user attitudes by emphasizing the technology's value.

In the context of AR-assisted hairstyling teaching systems, simple and intuitive operations can lead to more positive user attitudes and increase their intention to continue using the technology. Research by Elnadi & Gheith (2022) showed that users of ride-hailing apps perceived as easy to use reported higher satisfaction and trust, boosting their intention to keep using the service. Wu et al. (2024) found that in EFL students using AR-assisted systems, perceived ease of use positively influenced both perceived usefulness and attitudes, which then enhanced their intention to continue using the technology.

Attitude also mediates the relationship between perceived usefulness and behavioral intention. When students believe AR-assisted teaching systems improve learning outcomes, they develop positive attitudes that strengthen their intention to use the technology. Paramita and Hidayat (2023) noted that users who view mobile

banking services as beneficial are likely to form positive attitudes, reinforcing their intention to use these services. Overall, attitude is a key mediator between perceived usefulness and users' behavioral intentions.

Conclusion

This study designed an AR-assisted hairdressing education system to facilitate self-directed learning for students preparing for Taiwan's C-level beauty and hairdressing certification, eliminating the necessity for instructor supervision. The research also investigated the relationships between perceived ease of use, perceived usefulness, attitude, and behavioral intention, as proposed by the Technology Acceptance Model. The results demonstrated that AR technology significantly enhanced students' comprehension and practical application of hairdressing techniques, thereby improving their preparedness for certification exams. The system provided clear technical guidance and enabled repeated practice of essential skills, fostering self-learning capabilities and enhancing overall learning outcomes.

The AR system was both user-friendly and intuitive, significantly enhancing students' perceptions of its usefulness and cultivating positive attitudes toward it. Its convenience helped to alleviate psychological barriers and minimize the time costs associated with the learning process, thereby fostering greater acceptance and trust in the technology among students. The perceived ease of use played a vital role in enhancing both the perceived usefulness of the system and students' overall attitudes toward it.

Perceived usefulness was a critical factor influencing students' attitudes and behavioral intentions. When students recognized that the augmented reality (AR) system significantly enhanced their learning efficiency and skill development, they demonstrated a more positive attitude toward the technology and a stronger intention to continue using it. Furthermore, attitude functioned as an essential mediator between perceived ease of use, perceived usefulness, and behavioral intention, effectively translating students' perceptions of the technology into actionable intentions.

The perceived ease of use did not significantly affect students' behavioral intentions. Instead, students were primarily focused on whether the system could help them achieve their learning goals, rather than on how easy it was to operate. This indicates that in task-oriented learning environments, perceived usefulness is more influential than perceived ease of use.

AR technology has not only enhanced learning efficiency and outcomes but has also removed the time

and space limitations associated with traditional learning methods. This advancement allows students to cultivate self-directed learning skills. This study provides empirical evidence supporting the use of AR technology in vocational education and emphasizes the importance of improving perceived ease of use and perceived usefulness during the design and implementation of these systems. Future research could investigate the application of AR technology in other vocational education sectors and explore its long-term effects and adaptability among various learner demographics.

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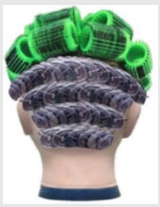
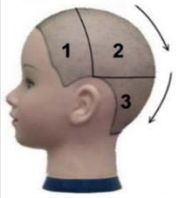
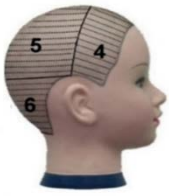
Appendix

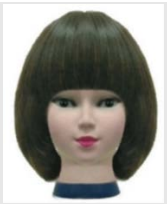
Create recognition graphics and instructional videos for an augmented reality (AR) application based on the 12 practical test items required for certification by the Workforce Development Agency of the Ministry of Labor under the "Class C Female Beauty Technician" program. Each test item will be organized into an independent learning module, complete with a specific identification marker and an instructional video assigned to it.

Standard Cold Perm				
Marker A	Marker B	Marker C	Marker D	Marker E
				
Video-A	Video-B	Video-C	Video-D	Video-E
Fan-Shaped Cold Perm				
Marker F-A	Marker F-B	Marker F-C	Marker F-D	Marker F-E
				

Video-F-A	Video-F-B	Video-F-C	Video-F-D	Video-F-E
Haircut			**Full Hair Styling I**	
Marker HC-Horizontal	Marker HC-Slash	Marker HC-Backslash	Marker Side-Roller	Marker Side-Curl
				
Video-Hori	Video-D-F	Video-D-B	Video-Roller	Video-Curl

Full Hair Styling II		**Full Hair Styling III**	
Marker Seamless Hair roller	Marker Seamless hair rollers and clip curls	Marker Seamless-Hand roll	Marker Seamless hand roll and clip roll
			
Video-SHR	Video-SHRCC	Video-SHR	Video-SHRCC

Dyeing White Hair Black		***Bleaching or Hair Dyeing***	
Marker DWHB-L	Marker DWHB-R	Marker BleachDye-L	Marker BleachDye-R
			
Video-WB-L	Video-WB-R	Video-BD-L	Video-BD-R

Blow-drying		
Marker BL-Horizontal	Marker BL-Forward slash	Marker BL-Backslash
		
Video-BLHor	Video-ForSlas	Video-BacSlas

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The Transformative Aesthetics of Extended Reality Technology in Immersive Performances: Case Studies on *The Ocean* and *Dome of the Gods*

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This paper explores the transformative aesthetics of Extended Reality (XR) technology, which integrates Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), within immersive performances. Utilizing a practice-based research methodology, the study analyzes two distinct XR-inflected works: *The Ocean* (2024) and *DOME of the GODS* (2024). *The Ocean* employs AI-generated visuals (Stable Diffusion, Deforum), real-time data visualizations (Processing), and tactile installations with Arduino microcontrollers to create a multi-sensory, polychronic embodied environmental narrative focused on the Anthropocene and ecological critique. In contrast, *DOME of the GODS* pioneers synchronous hybrid performance by using wearable biophysical sensing (sEMG, ECG), motion capture, and low-latency protocols (WebRTC, NDI) to link physically and virtually distinct performers. The results demonstrate how XR re-negotiates the theatrical contract, transforming spectatorship into active, experiential participation, and realizing a Post-digital Aesthetics where physical and virtual elements are fused. Both works exemplify how innovative artistic practice generates critical theoretical insights into presence, audience agency, and the ethics of eco-imagination.

Keywords - Audience Agency, *DOME of the GODS*, Extended Reality, Immersive Performances, Practice-based Research, *The Ocean.*

Relevance to Design Practice - This research provides a framework for designing hybrid immersive experiences that utilize real-time data (including physiological and environmental inputs) and low-latency systems for synchronous collaboration and audience engagement. It offers models for integrating generative AI with tangible installations to create multi-sensory, interactive spaces for storytelling, ecological reflection, and human-computer co-creation.

Introduction

Contemporary computational technologies merge the real and the virtual to create a human-computer interactive environment. From early augmented reality (AR) and virtual reality (VR) to the most recent mixed reality (MR) and extended reality (XR), virtual technologies continuously enhance the feedback loop among the virtual environment, the real world, and the user (or the participant) to strengthen the authenticity of experience. As a technology that integrates AR, VR, and MR, XR is a human-centric medium that combines real and virtual environments. It transcends space, merges physical reality with the virtual, and allows for the summoning of objects and devices at will. It also amplifies human senses, memory, and perception to an extraordinary degree. XR can completely subvert human-computer interaction by adapting to the scene's needs, giving participants greater freedom and choice, enhancing the diversity of narratives, and truly achieving an "anytime, anywhere, ubiquitous" possibility. The advent of XR technology has significantly impacted the forms of expression in the performing arts. This combination of digital enhancement and live performance similarly creates multi-sensory environments that challenge traditional narrative methods, audience reception, and the very structure of theatrical representation.

As Bochicchio and Miccoli (2024) state, integrating XR into a theatrical context transforms passive onlookers into active participants, inviting them to navigate and influence the performance through immersive technology. This democratization of performance encourages the audience to engage with the narrative and the artistic creation process, reshaping their relationship with the artists and the environments they create. The physical boundaries between the audience and the stage become blurred, fostering a collective experience that is both intimate and expansive. These shifts in audience engagement are particularly relevant in an era where audiences seek interactive experiences beyond traditional screen-based entertainment. Santini (2024) also denotes that XR transcends traditional boundaries, enabling artists to explore new dimensions of creativity in their work. The fusion of multiple media—digital animation, sound design, and interactive installations—allows artists to create multidimensional and participatory narratives. Immersive performances that apply XR technology also redefine the relationship between the audience and the narrative. At the core of this transformation is the ability of XR environments to dissolve the barriers between performer and audience, creating an interactive narrative space that supports audience autonomy. When audience members put on a VR headset or use an AR application, they can traverse physical and narrative boundaries, enabling a multifaceted exploration of the performance (Young et al., 2024). This immersive perception enhances the sensory experience and engages individuals as participants differently from traditional theatrical viewing.

Moreover, XR technology plays a key role in the evolution of traditional theatrical forms. The re-contextualization of existing practices, such as live theater, dance, and opera—by integrating these innovative technologies—has given rise to hybrid forms. These forms preserve their existing elements while also catering to contemporary sensibilities. Accordingly, the increase of XR in the performing arts can be

considered a response to the changing expectations of audiences in an increasingly digital world, where immersive participation is often contrasted with traditional narrative structures. At the same time, the continued integration of XR into the performing arts signifies a paradigm shift in how immersive performances are conceived and experienced. By fostering more profound audience engagement, expanding artistic expression, and evolving traditional theatrical forms, XR reflects the complexity of contemporary cultural appreciation and highlights modern technological art's interactive and immersive nature. This paper will take two immersive XR works of art, "*The Ocean* (2024)" and "*Dome of the Gods* (2024)" as cases, and delve deeply into their characteristics of immersive aesthetics, technical application aspects, and creative practice analysis.

Immersive Aesthetics: Redefining Perceptual Experience and Audience's Participation

The contemporary arts landscape faces significant changes, particularly through integrating innovative theatrical practices and advanced digital technologies. Immersive theatre and XR are leading this transformation, as they are two distinct yet increasingly interconnected fields that redefine how audiences engage with artistic expression. It is essential to understand their unique characteristics and how they reshape audience participation and perceptual experiences to grasp the future direction of digital performance.

Revisit the Concept of "Immersion"

The English word "immersion" has Latin roots, stemming from the word "mergere," which means "to plunge into." Its original meaning referred to a physical submersion, and only later did it evolve to mean being absorbed in a particular state or situation. The Cambridge Dictionary defines "immersion" as "becoming completely involved in something." Simply put, the original definition emphasized the physical state of being fully submerged in a liquid or similar environment.

Although "immersion" has different definitions and connotations across various fields, it generally refers to being mentally and physically absorbed and focused on a virtual environment or situation. American narrative scholar Marie-Laure Ryan suggests that the term has long been used metaphorically and informally to describe deep engagement with a text or task. Now, immersion has taken on a new theoretical dimension by connecting with Virtual Reality (VR) technology (Ryan, 2022). Virtual reality is an immersive, interactive computer experience created using digital technology (Pimentel and Teixeira, 1992). This concept was developed by its creators starting in the 1980s and 1990s. Influenced by VR, immersion is now applied to other media, including digital media (video games) and traditional media (film, television, theater, visual arts, and literature).

Immersivity can be considered a desired characteristic of a work, concerning its form and content. It can also be viewed as a resource issue for the entire medium. The metaphorical basis of immersion is wholly absorbed in a liquid element different from the user's typical environment. Therefore, immersion involves replacing the user's current world (or reality)

with an alternative virtual reality. Although symbols of the medium create this virtual reality, the user achieves a psychological sense of immersion when they feel it is unmediated or transparent, much like experiencing the real world (Ryan, 2022). To some extent, the "disappearance of the medium" from subjective consciousness is widely considered a key immersion condition.

Another concept that VR researchers associate with immersion is presence (Lombard and Ditton, 1997). Immersion is experienced when something that does not belong to the user's physical environment is perceived as being "here," or when the user feels they have been transported "there," to a different location from their actual one. However, as Gordon Calleja (2011) points out, the relationship between presence and immersion has problems. Is presence a synonym for immersion, or is it one of its many forms or factors? Mel Slater (2003) tends to view immersion (or immersivity) as an objective characteristic of a system or medium, while considering presence as the subjective impact of these characteristics on the user.

Undoubtedly, XR enhances immersive experiences by incorporating more sensory input and additional wearable technologies and leveraging generative AI to create faster, more realistic, and more interactive virtual environments. This makes XR more accessible and widely adopted in markets beyond gaming, including immersive simulations, performance arts, virtual historical explorations, virtual experiments, and augmented museum tours.

Immersive Theatre and XR Technology

As mentioned, XR, an umbrella terminology encompassing VR, AR, and MR, represents a paradigm shift in human-computer interaction. Compared to other virtual technologies, XR enhances interactivity through more natural and direct user interfaces. It also provides more realistic simulations for training and education, boosts productivity with virtual workspaces and remote collaboration, and offers more immersive entertainment experiences. Furthermore, it can provide alternative interaction methods for people with disabilities. Immersion is central to this technological revolution—the psychological state of being absorbed in a virtual or augmented environment. The immersive theater evolved in response to a growing demand for interactive and experimental narration forms that transcend conventional spectatorial roles. Traditionally, the public in the theaters of Proscenio are passive observers; however, the immersive theater challenges this paradigm by promoting active participation and blurring the lines between the interpreter and the spectator. This participatory nature allows exploring multicapa narratives where personal elections can influence history and results (Bochicchio and Miccoli, 2024). Integrating XR technologies improves this immersive experience by offering richer and more complex environments and interactions that deepen narrative commitment. For example, a theatrical performance that AR can transport to different places or epochs, while virtual reality can wrap them in entirely manufactured worlds, inviting direct participation in the narrative that develops. These technologies introduce amplitude and depth in the narration of stories by allowing non-linear narratives and interactions of multifaceted

characters that depend on the audience's options (Young et al., 2024).

Immersive theatre represents a significant departure from traditional theatrical formats by breaking down the usual barrier between the stage and the audience. This genre actively involves audiences in the performance space, inviting them to play an essential role in the unfolding narrative. Unlike conventional theatre, which typically features a proscenium arch and fixed seating in an auditorium, immersive theatre immerses the audience directly into the action. This shift transforms individuals from passive spectators into active participants, encouraging a deeper personal engagement with the story. The essence of immersive theatre lies in its careful design, aimed at creating a thoroughly engaging sensory experience. Every aspect of stagecraft—from intricate set design and dynamic lighting to evocative soundscapes and even thoughtfully chosen scents—is used harmoniously to tell the story (Wellham, 2024). The performance may occur around the audience or involve them in specific tasks and interactions. This approach encourages participants to explore the performance space, engage physically with the set, and feel a deep sense of being transported into a new reality. The active involvement is intentionally designed to evoke heightened emotional and physical responses from everyone involved.

In addition, the evolution of immersive theater through the incorporation of XR technologies reflects broader cultural and technological changes in society, resonating with the growing familiarity of the public with digital environments. These technologies both increase physical interaction in a performance environment and take advantage of the emotional and cognitive participation of the audience, which facilitates a more personalized experience. For example, an AR component in immersive performance can highlight specific elements of the set or characters and guide the audience's approach while allowing spontaneous discoveries promoted by the user. Consequently, XR technologies redefine sensory perception within theatrical experiences, thus improving the emotional resonance of narratives (Bochicchio and Miccoli, 2024).

Participants in immersive productions are provided with specific moments of action and input. While these moments influence the narrative, their primary effect is often on the participant's personal experience rather than the overall story structure. This setup encourages involvement without completely dictating the plot. Immersive productions strategically utilize diverse environments, ranging from expansive multi-level buildings to open outdoor spaces, allowing audiences to choose how they engage and move through various scenes or levels.

Four key components foster audience integration into these performances: "real space," where the physical environment becomes an essential part of the play; "sensory engagement," such as blindfolding participants to enhance their sense of hearing; "movement within the space," and "the manipulation of time within the narrative" (Sakellaridou, 2014: 13-38). This fundamental shift, where the audience transitions from passive observers to active agents, represents a re-negotiation of the theatrical contract. Traditional theatre presents a story to an audience, while immersive theatre invites the audience into the story. The concept of a polychronic narrative, where agency is granted but often curated, highlights a delicate balance between audience freedom and artistic control. This redefinition transforms the

audience's engagement from a cognitive processing of a presented narrative to an experiential processing within a lived narrative. The implications for the performance's memory formation, emotional impact, and personal relevance are significant, as the experience becomes akin to a personal journey rather than a mere performance. This active agency also lays a crucial groundwork for the powerful enhancement that XR can bring to sensory engagement and participation.

Methodology: Art Practice as a Research Method for Knowledge Production

Art practice expresses human intellect that can apply knowledge and transform past experiences to address new problems. In other words, creative practice, academic research, and theoretical generalization are essential in practice-related research. This process begins with an innovative practice led by the artist, moves to naturalistic field research, and then to the abstraction of theories and concepts. Theory and practice, in turn, feed back into the creative project and research. Therefore, while the general flow is from practice to theory, the application involves more intricate details. As shown in the figure below, practice provides data for research, and in the same way, research can directly inform practice through an iterative design process. Various forms of research provide a grounding for theory, while theory provides sensitizing concepts for research. Ultimately, theory can generate concrete, practical design outlines and patterns. Similarly, researchers can gain theoretical insights from the critical analysis and documentation of practice.

Research methods focused on practice have been widely used in creative arts research, but their application varies across different disciplines. For example, design research focuses on understanding the nature of practice and how to improve it, rather than creating or reflecting on new artworks. Creative arts, including new media art, focus on the creative process and the final work produced. Therefore, the artwork becomes a crucial part of understanding the practice. In this sense, practice and research aim to generate new knowledge that can be shared and scrutinized. Simply put, practice-based research is innovative research aimed at acquiring new knowledge, primarily through practice and its outcomes. This means that practice and research are two interdependent and complementary processes, yet they are distinct. Therefore, it's difficult to claim that "research is practice" or "practice is research," as treating these two activities as the same can lead to a misunderstanding of the "practice-based research approach."

Research involves seeking knowledge that does not yet exist, including finding new knowledge and the knowledge itself. When considered public research, it differs from information collected for personal value. We expect this research to produce insightful, helpful, and groundbreaking expertise. Such research must be novel in its results and methodology and subject to public review. Research must contribute to the body of knowledge rather than just benefiting an individual. This is why research differs from practice; each has a distinct meaning.

There are now many different facets and interpretations of practice-related research, such as “research as practice” and “practice as research,” but equating these two concepts is not entirely appropriate. Smith and Dean (2009) proposed a model for the creative arts and research process, seeing it as a continuous, iterative cycle between “practice-led research” and “research-led practice.” There are many iterative processes in each activity cycle (generating ideas, researching, etc.). During this time, practitioners identify functional or optimal results from each task. Furthermore, Candy and Edmonds (2018) argue that it’s essential to differentiate between “practice-led research” and “practice-based research,” suggesting the following distinction:

1. The research is practice-based if a creative artifact is the basis of the contribution to knowledge.
2. If a study primarily leads to new understandings about practice, it is practice-led.

This distinction is beneficial when the materiality of a creative work influences the creative process and outcome. For a practice-based researcher, producing a work is paramount, and the insights gained from making, reflecting, and evaluating can feed directly into the work itself. On the other hand, practice-led research does not rely on creating a work. Instead, it is built on the practice itself. For example, a curator might dedicate their research to finding a methodology for exhibitions, studying the nature of exhibition practice, and identifying relevant methods from existing curatorial approaches to develop a new practice. The outcome of this new curatorial work might share certain principles, patterns, or frameworks.

Accordingly, practice-based research emphasizes the production of a creative work because a complete understanding of this research process can only be experienced during the creation of the work. Therefore, practice-based research must provide a substantial contextual discussion of the work, articulating a way to appreciate the new creative work. This discussion is a critical analysis that not only dissects the work’s originality and position but also proposes standards and a basis for judgment.

The work is fundamental to practice-based research because it is the primary way to understand the new knowledge generated during the process, highlighting the artwork’s role and status in this type of research. The work created by the practitioner is part of the practice, and the creation process provides an opportunity for exploration, reflection, and evaluation. While the final product or object is often the focus of a practitioner’s practice, a work is more than just an object; it can be an experiment or something quite intangible. Therefore, the term “artwork” should be viewed broadly. It can be an object (like a painting), have a specific duration (such as a piece of music or a film), be ephemeral (a performance or an exhibition), or even be an interview. As such, artwork should encompass creations that are both notionally artworks and non-notionally artworks. In a practice-based context, the work’s role is central to the research process, which also involves how the research outcomes are shared.

In conclusion, a key characteristic of practice-based research is that it does not conform to traditional research norms. Its primary work is the production of a work—whether a visual or sonic object, an installation, or a performance—which serves as the basis of

the research. Most importantly, practice-based research is "research," not just practice. This means that the final research outcome may be presented as a thesis. Still, it must focus on the process of making a specific artwork, how that creative process is understood, and a discussion of the basis for the artwork's "innovation." To the extent that, through exhibitions and work annotations, the research will be organized into a systematic understanding of "immersion," offering new insights and perspectives to future viewers, practitioners, and readers.

XR in Practice: Immersive Environmental Narratives

While the preceding sections have outlined the theoretical frameworks, historical trajectories, and aesthetic principles underlying XR and immersive performance, the following part of the article shifts the focus from conceptual analysis to artistic praxis. It examines how XR-inflected immersive environments can function as critical storytelling arenas where technological innovation, sensory engagement, and environmental discourse intersect. By exploring concrete examples from recent artistic productions, this chapter illustrates how extended reality technologies are integrated into large-scale, multi-sensory installations to redefine audience participation, translate environmental data into perceptual experience, and provoke ecological reflection. These case studies emphasize the technical sophistication of XR-driven works and their capacity to operate as affective and cognitive catalysts—immersing audiences in narratives that oscillate between empirical reality and speculative imagination. The first work of immersive art, *The Ocean* (2024), demonstrates how immersive theatre can transform an exhibition space into a dynamic oceanic environment that encourages the audience to reflect on contemporary sustainability and pollution issues. The second work of art, *DOME of the GODS* (2024), reimagines the immersive space of a dome as an interactive site for real-time, synchronous performances, where performers in different locations interact via biophysical feedback and wearable devices to bridge virtual and physical spaces. Together, these works exemplify immersive environmental narratives that embody the transformative aesthetics of XR in practice.

The Ocean (2024) – Reflective Immersive Theatre at U-108 SPACE, NTMoFA

The Ocean (2024) is a reflective, immersive theater project developed by the Ping-Yeh LI Technology and Art Laboratory and showcased at U-108 SPACE, National Taiwan Museum of Fine Arts (NTMoFA) in Taichung, Taiwan, between May and September 2024. *The Ocean* emerges as an interdisciplinary and reflective immersive theatre piece addressing the Anthropocene—framing the ocean not only as a metaphor of natural life but also as a geological and ideological construct shaped by human interference. By identifying pollutants such as plastics and concrete within geological strata, the work invites audiences to engage with the epochal condition of the Anthropocene, prompting a critical inquiry into human–nature relations in a post-digital, posthuman era.

The work transforms U-108 SPACE—a 14-meter-diameter circular floor enclosed by a 4.75-meter-high cylindrical wall—into a "container-space" that envelops the audience

within four dimensions of 'ocean': Life, Information, Reflection, and Hope. This spatial design foregrounds embodied perception and immersive resonance, inviting participants into technological-perceptual loops reflecting marine-environmental futures.

The first part, The Ocean of Life (Figure 1), depicts the ocean as the cradle of existence, beginning with cellular division and plankton as the marine food chain's foundation. Fish geometries and intelligent marine mammals, such as whales and dolphins, highlight the richness of life. At the same time, hieroglyphic-like symbols reflect human civilization and the enduring mysteries of the ocean. The second part, The Ocean of Information (Figure 2), explores how technology mediates our understanding of marine environments. Utilizing datasets from Taiwan's Ocean Conservation Administration, Processing visualizations present microscopic patterns of observation-station data and macroscopic evolutions of two decades of records, culminating in immersive binary codes that symbolize a data-driven perception of nature. The third part, The Ocean of Reflection (Figure 3), addresses ecological damage, portraying blackened corals, distorted marine life, and plastic debris. Generated with AI neural networks, these visuals are a critical mirror of human impact on marine ecosystems. The final part, The Ocean of Hope (Figure 4), envisions future coexistence, where humans and cetaceans travel in a particle-formed ocean. The finale transforms a whale into a starry cosmos, symbolizing aspiration and renewal. Complementary installations—glowing paper corals with LED illumination and a marine waste seal skull—reinforce the exhibition's ecological critique and optimism.

Figure 1. The Ocean of Life.

Figure 2. The Ocean of Information.

Figure 3. The Ocean of Reflection.

Figure 4. The Ocean of Hope.

All photos are provided by the National Taiwan Museum of Fine Arts.

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Photography by ANPIS FOTO, Wang Shih-Pang.

Technological Embodiment

The Ocean (2024) integrates a range of advanced media technologies to actualize its multi-dimensional oceanic narrative: generative visuals created with Stable Diffusion and Deforum, dynamic projections programmed in Touch Designer and Processing, enhanced visual effects designed in Adobe After Effects, interactive physical light controls using Arduino microcontrollers, and real-time visualizations of Taiwan's seawater quality data using Processing. Physically, the piece employs an island-like installation embedded with found materials—ocean plastic debris, metal, paper, and sea sand—integrated with immersive projection and lighting. This fusion of digital animation and tactile artifacts creates a hybrid narrative: an oscillation between material residue and speculative future visions, making the connection between human-induced environmental wear and lush creative reimagination tangible.

To enhance the sense of immersion in the projection space, we designed an island-shaped installation placed at the center of U-108 SPACE. This installation uses marine sand and ocean waste plastics to construct a coral-like tree. Additionally, we utilized materials such as iron wire, translucent paper, and cellophane to create paper-based corals through rolled-paper sculpting techniques. Within these paper corals, we embedded Arduino microcontrollers, RGB LED panels, and relays to control the color variations of the corals' illumination. Coordinated with the four segments of immersive visual projections, the paper corals present distinct lighting effects and performances, enhancing the overall immersive experience (Figure 5).

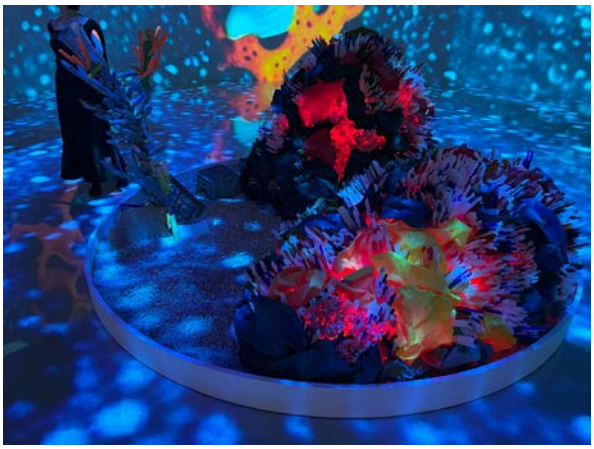

Figure 5. Physical installation of The Ocean (2024) assembled with an RGB LED module, Arduino, ocean plastic wastes, paper, metal wires, and coral bone.

***DOME of the GODS* (2024) - Experimental Prototype for Synchronous Hybrid Performance at Future Vision Lab 2024, C-Lab**

DOME of the GODS (2024) emerges as an ambitious exploration into mixed-reality performance, aiming to establish a coexistence of virtual and physical realities within the

theatrical space. This work integrates motion capture technology, physiological sensing, and sophisticated performance elements to craft a multi-sensory, full-sensory immersive theater experience within a non-traditional dome structure. Drawing thematic inspiration from classic creation myths, the project articulates a narrative thread exploring creation, belief, betrayal, and salvation, fundamentally challenging the design of virtual-physical integration for multi-participant, synchronous presence.

The mythologically inspired narrative explores the gradual convergence of the virtual and physical worlds. The climax is framed as a rebellion, driven by the biophysical feedback loop (electrical stimulation triggered by physiological changes). When the physical world prevails, the virtual deities observe the physical dome theater, providing VR audiences with a divine perspective. Simultaneously, a massive projection of the virtual deity appears for the physical audience, heightening the dramatic tension. This design utilizes real-time adaptive creation, where performers' movements are guided by physiological data, ensuring each show is a dynamic and unique experience.

This experimental prototype focuses on developing a system for synchronous performances bridging distinct virtual and physical domains. The core of the project involves fusing advanced technological systems to enhance storytelling and audience engagement. The integration of virtual and physical dimensions is predicated on the creation of a "shared space" where time and space converge, requiring rigorous technical synchronization. The system facilitates multi-dimensional participation, encompassing the involvement of on-site and online audiences, and the reciprocal influence between performers in both realms. This approach aligns with the lineage of works—such as Yacov Sharir's *3D Embodied* (2013) and Anarchy Dance Theatre's *CyborgEros* (2023)—that utilize motion capture technology and live digital interaction to achieve theoretical synchronicity and redefine the boundaries of the performance space. Moreover, the project foregrounds real-time adaptive creation, treating the performance not as a fixed product but as a continuous "dialogue" that dynamically reshapes the artwork's meaning and identity through biophysical interaction.

System Design and Performance Environment

The customized system integrates wearable technology, biophysical sensing devices, and real-time data transmission protocols to realize synchronous hybrid improvisation (Figure 6).

1. Wearable Biophysical Sensing Devices: Dedicated wearable devices were developed to capture Surface Electromyography (sEMG) and Electrocardiography (ECG) signals.
2. Transmitter Devices: Worn by performers in the physical space, these devices utilize an ESP32 microcontrollerand sEMG sensors to capture muscle activity and an ECG device for heart rate data, transmitting both in real-time.
3. Receiver Devices: Developed for online performers, these devices use an ESP32 to receive data. Crucially, when

a physical performer's muscle activity exceeds a preset threshold, the corresponding online performer receives a controlled electrical stimulation. This design compels intuitive, real-time responsive movements from the virtual performer, establishing an embodied, dialogical link between the two spaces.

4. Real-time Data Transmission: WebRTC ensures low-latency data transmission, while the NDI protocol facilitates real-time video streaming between the virtual and physical environments. A unique feature involves dual fisheye cameras capturing and stitching the physical space, allowing virtual audiences, at the narrative climax, to perceive the physical world as enclosed within a "crystal ball" (Figure 7).

Figure 6. Performers wearing the transmitter and receiver devices.

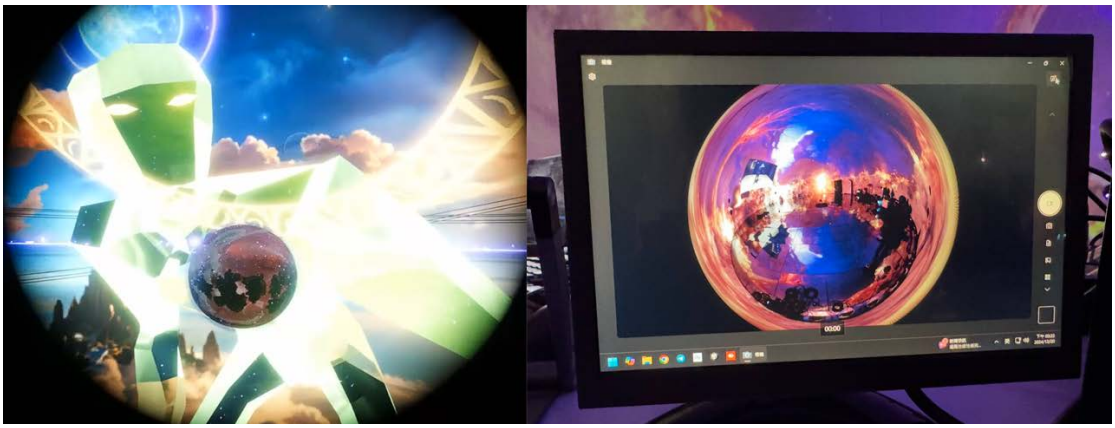

Figure 7. Real-time video transmission from the physical space to the virtual realm.

The prototype was implemented across two distinct performance contexts: the first physical space utilizes dome projection technology to create a hemispherical visual environment complemented by a directional immersive sound system. Additionally, a virtual environment is accessible via VR headsets or a PC (keyboard and mouse). Performers are tracked by an optical motion capture system and interact with the audience through their virtual avatars (Figure 8).

Figure 8. Motion capture setup for the virtual performance.

Interpretive Synthesis

Through the description of two works of art, one can realize that *The Ocean* exemplifies how XR-inflected immersive art can articulate eco-critical narratives: the physical space acts simultaneously as a sensory container and a speculative archive. Audiences are not mere spectators but active participants—sensors within a living media environment—whose movements, perceptions, and emotional responses become integral to the unfolding dramaturgy. This aligns with the theoretical framing of immersion as both a psychological absorption and a designed condition of presence. By surrounding visitors with 360-degree projections, responsive lighting, and tactile installations, *The Ocean* realizes the "disappearance of the medium" Ryan (2022) described, producing an unmediated perceptual flow in which ecological data and artistic imagination converge. At the same time, the work echoes Slater's distinction between immersion as system quality and presence as subjective impact: the technological integration of AI-generated visuals, open-data projections, and Arduino-controlled corals constitutes the immersive system, while the audience's felt sense of coexisting with marine life or witnessing coral bleaching embodies presence. The four narrative segments—Life, Information, Reflection, and Hope—structure a polychronic experience, where temporal layers of the ocean (prehistoric life, contemporary data, degraded ecosystems, and speculative futures) coexist, inviting audiences to navigate across temporalities much like immersive theatre participants choose narrative pathways.

Moreover, *The Ocean* foregrounds audience agency in subtle yet meaningful ways. While the central storyline is pre-designed, the embodied act of walking within the cylindrical space, encountering physical coral installations, and experiencing shifting sensory intensities generates personalized micro-narratives. In this sense, the project re-negotiates the theatrical contract identified by Sakellaridou (2014): rather than passively consuming a spectacle,

audiences are immersed in a lived narrative in which ecological crisis is not abstractly presented but somatically experienced.

Finally, the piece demonstrates how immersive aesthetics extend beyond sensory novelty toward ethical and ecological imagination. Integrating found ocean debris into the scenography and transforming a whale into a cosmic constellation, *The Ocean* situates participants in a liminal zone between critique and aspiration. Here, the XR environment amplifies sensory perception and catalyzes reflection on humanity's entanglement with marine ecosystems, offering both a mirror of damage and a horizon of hope.

On the other hand, inspired by mythology, the performance narrative explores the gradual convergence of the virtual and physical worlds throughout the show in *DOME of the GODS*. The dual-space narrative emphasizes the interaction between performers, symbolizing the interconnectedness of these realms. The story's climax is a rebellion between the physical and virtual worlds, depicted through improvised performances driven by biophysical feedback, such as electrical stimulation triggered by physiological changes. When the physical world prevails, the dome theater reveals itself to the virtual deities, allowing VR audiences to observe the physical world's existence from a divine perspective. Simultaneously, the physical audience sees a massive projection of the virtual deity, bringing the narrative to its climax.

Real-time adaptive creation plays a key role in the performance design. Performers in physical and virtual spaces rely on biophysical feedback (such as heart rate and muscle activity) to guide their movements. This method allows the performance to unfold spontaneously and dynamically, making each show a unique experience.

A mixed-methods research approach revealed strong audience affirmation for the performance, particularly its virtual-physical integration and technical presentation, with high enthusiasm reported for the immersive experience (93.9%) and the technical application (56.3%). Feedback particularly highlighted the 360-degree spherical panorama and the ability to view reactions across different locations. Despite the positive reception, the prototype faced significant challenges: real-time video streaming latency during peak network traffic and fluctuations in the signal quality of the biophysical sensing devices due to movement. Narratively, audiences cited the abstractness of the text and the lack of clarity regarding character symbolism and structural coherence between performance segments. These findings not only validate the appeal and potential of hybrid performance systems but also clearly define future research directions, pointing toward the necessity of improving narrative coherence and ensuring technical stability to fully realize the expanded boundaries of the performing arts (Figure 9).

Figure 9. The climactic appearance of the virtual deity in the physical dome theater.

Comparative Reflection & Theoretical Resonance

The contemporary integration of XR into the performing arts signals a paradigm shift, transforming spectatorship into active participation and dissolving the traditional proscenium arch. The theoretical discourse surrounding immersion and presence—where immersion is the objective quality of the system and presence is its subjective impact (Slater, 2003)—finds concrete articulation in recent XR-inflected works. The case studies of *The Ocean* (2024) and *DOME of the GODS* (2024) exemplify this trend, demonstrating how practice-based research generates new knowledge by challenging the boundaries of the theatrical contract (Sakellaridou, 2014) and recontextualizing traditional forms through technological innovation. While both works utilize non-traditional spaces and prioritize a multi-sensory, immersive aesthetic, they diverge significantly in their mode of audience agency and their application of virtual-physical integration.

The theoretical principles of immersion and presence find dynamic articulation in the case studies of *The Ocean* and *DOME of the GODS*. Both works utilize XR to transcend passive spectatorship, but they diverge in their application of technology to define embodied environmental narratives, audience agency, and the ethics of eco-imagination.

1. XR and Post-digital Aesthetics: Both productions embody a Post-digital Aesthetics, where the distinction between digital-born and physical elements dissolves into a single, cohesive sensory experience. This aesthetic is characterized by the deliberate fusion of advanced computational technologies with tangible, found, or traditional materials. *The Ocean* achieves this characteristic through sensory synthesis, merging generative AI visuals (Stable Diffusion) and real-time data visualizations (Processing) with the tactile presence of ocean plastic debris and Arduino-controlled paper corals. The aesthetic is one of hybrid narrative, where the "material residue" of the Anthropocene is integrated directly into the speculative future visions, challenging the audience's perception of the medium as unmediated. On the other hand, *DOME of the GODS* focuses on synchronous hybridity—the digital is not just content but the connective tissue itself. Biophysical

sensing (sEMG, ECG) and low-latency WebRTC and NDI protocols integrate the virtual and physical performers into a singular, dynamically responsive system. The aesthetic shifts from content visualization to real-time system performance, making the technological framework itself the primary aesthetic object.

2. Embodied Environmental Narratives: Both works utilize their immersive structures to engage the audience's physical and cognitive faculties in experiencing environmental themes, creating Embodied Environmental Narratives. *The Ocean* creates a reflective narrative framed around the Anthropocene. The audience is physically immersed in a "container-space" where the ocean is presented as a geological and ideological construct. The multi-sensory environment allows the ecological crisis to be somatically experienced rather than abstractly observed. The journey through the four segments—Life, Information, Reflection, and Hope—is an affective and cognitive catalyst, prompting reflection on humanity's entanglement with marine ecosystems. Instead, *DOME of the GODS*, "environment" is primarily the hybrid performative space itself while drawing on creation myths (a foundational narrative of environment and origin). The embodiment is centered on the performer's physiological data, which dictates the narrative's tension and climax. The environment becomes a battleground between the virtual deities and the physical realm, using the dome structure and the biophysical feedback loop to stage an embodied, albeit metaphorical, conflict over spatial dominance and convergence.
3. Audience Agency and Temporal Poetics: The integration of XR renegotiates the theatrical contract by transforming the audience into participants, which requires a new understanding of audience agency and the manipulation of temporal poetics within the narrative. In *The Ocean*, agency is locational and interpretive. The audience chooses their path and pace within the cylindrical space, generating personalized micro-narratives. The Temporal Poetics are polychronic: the four segments overlay prehistoric, contemporary, degraded, and speculative futures, inviting navigation across temporal layers. The agency granted is curated, enhancing personal experience rather than fundamentally altering the plot. Differently, agency in *DOME of the GODS* is perceptual and transactional. Audiences (both physical and VR) experience complementary perspectives, witnessing the narrative convergence from distinct vantage points (e.g., the VR audience viewing the physical world as a "crystal ball"). The temporal poetics are dictated by real-time adaptive creation, where the moment-to-moment biophysical feedback and improvised performance ensure the show unfolds spontaneously and dynamically, making the present moment of performance inherently unique and temporally unstable.

4. Ethics of Eco-Imagination: Both works undoubtedly contribute to the ethics of eco-imagination by using immersive aesthetics to generate a space for both critique and aspiration regarding contemporary global issues. *The Ocean* directly tackles ecological critique by integrating ocean debris into the scenography and presenting visuals of bleached corals and pollution. The ethical component is clear: the work is a "mirror of damage". It concludes with a vision of renewal—the whale transforming into a cosmic constellation—offering a "horizon of hope" and situating the participant in a liminal zone between degradation and ethical aspiration. In contrast, the ethical contribution of *DOME of the GODS* lies in defining the future of human and machine coexistence and the integration of physical and virtual bodies. By using involuntary physiological data (heart rate, muscle activity) to drive the performance, the work implicitly raises questions about technological control, bodily integrity, and the shared space in the mixed-reality era. Its exploration of real-time adaptive creation validates the potential of hybrid systems to enhance creative expression, providing a framework for future ethically conscious, trans-spatial collaborations.

In synthesis, *The Ocean* offers a refined model for immersive environmental narratives, where XR amplifies sensory perception to catalyze reflection on the human-nature entanglement. *DOME of the GODS* pioneers a real-time, synchronous, trans-spatial performance method, where biophysical data transcends physical location to achieve embodied presence across virtual and physical domains. Together, they testify to the power of XR in the performing arts to not only dissolve physical boundaries but also to redefine the very nature of storytelling, engagement, and creation itself.

Conclusion: Redefining Performance and Presence in the Age of XR

The transformative power of Extended Reality is fundamentally restructuring the performing arts landscape, moving the field beyond traditional forms into an era of synchronous hybridity and embodied participation. This paper utilized a practice-based research methodology to analyze two distinct yet complementary XR-inflected immersive works, *The Ocean* (2024) and *DOME of the GODS* (2024), demonstrating how innovative artistic praxis generates critical theoretical insights.

The analysis confirms that both productions have successfully harnessed XR to realize a Post-digital Aesthetics, where the boundaries between objective system quality (immersion) and subjective human experience (presence) are intentionally blurred.

The Ocean excels in sensory synthesis, integrating AI generated visuals with tactile installations to create a poly-chronic and somatically experienced embodied environmental narrative focused on the Anthropocene. Its strength lies in amplifying reflection and ecological critique through curated locational agency.

Conversely, *DOME of the GODS* pioneers synchronous hybrid performance, utilizing biophysical sensing and low-latency protocols to link geographically distinct performers and audiences. Its achievement is rooted in real-time adaptive creation, transforming performers' physiological data into a dynamic and dramatic element that facilitates a transactional temporal poetics. These two pieces of artwork collectively prove that XR does more than merely enhance traditional theatre; it renegotiates the theatrical contract entirely. By granting nuanced audience agency—from interpretive freedom in *The Ocean* to perceptual shifts in *DOME of the GODS*—the works shift engagement from cognitive processing to experiential processing within a lived narrative.

While demonstrating the immense potential of XR, the feedback from *DOME of the GODS* highlights critical challenges that define the next research frontier: improving technical stability (latency and sensor reliability) and strengthening narrative coherence within non-linear, adaptive structures. Future practice-based research must continue to focus on creating robust yet invisible systems, realizing the ideal of the "disappearance of the medium." In conclusion, the transformative aesthetics of XR have provided the performing arts with an unprecedented capacity for interdisciplinary innovation and profound audience engagement. The successful hybridization demonstrated by these two works secures the position of immersive technology as a fundamental, defining element of contemporary artistic expression.

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