Exploring the Effectiveness of a Unity-Based AR/VR Content Development Program: Focusing on University Students' Competency Improvement & Program Satisfaction

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This study examined the effectiveness of a Unity-based AR/VR content development training program implemented at a regional university in South Korea. Using a mixed-method design, the study investigated students' AR/VR major-related competency and AI competency through a pre–post survey, and assessed educational satisfaction after program completion. Participants were 18 undergraduate students who completed a 480-hour intensive program (June–October 2025). Quantitative data were analyzed using paired-samples t-tests, independent samples t-tests, and one-way ANOVA, and qualitative interview data from three volunteers were examined through content analysis. Overall, participants reported relatively high levels of AR/VR competency, AI competency, and program satisfaction. Male students showed significantly higher scores in several competency domains than female students. Pre–post comparisons indicated significant improvements in technical and practical AR/VR competence and in overall AI competency, particularly in cognitive and affective dimensions. Interview findings further suggested that employment-related opportunities and collaborative projects motivated participation, while perceived outcomes included enhanced major competencies, portfolio development, and improved collaboration. These findings provide evidence that intensive Unity-based training can support competency development and positive learning experiences among university students.

Keywords: AR/VR; Unity; competency development; AI competency; program evaluation; university students

I. Introduction

In South Korean universities, efforts to enhance students' employability and job-related competencies have been promoted not only through Ministry of Education–led financial support programs for higher education, but also through a range of project-based employment and labor market support initiatives primarily administered by the Ministry of Employment and Labor. These employment and competency development programs are designed to compensate for the limitations of academically oriented curricula and to strengthen the linkage between industry demand for human resources and university students' career development and employment pathways. In this sense, they function as formal and non-formal curricular interventions that support students' transition into the labor market by fostering employability competencies, and can be understood as forms of experiential and practice-oriented education (Lim, 2018).

Representative examples include the University Job Plus Center initiative administered by the Ministry of Employment and Labor, as well as the Industry Professional Practice (IPP) program, which provides practice-oriented training grounded in workplace experience. In addition, entrepreneurship education supported by the Ministry of SMEs and Startups and field-based internship and industry–university cooperation programs promoted by the Ministry of Trade, Industry and Energy have been implemented to strengthen university students' employability and job-related competencies.

Empirical studies have reported that university-based employment support systems exert significant effects on students' job preparation behaviors and their perceived job-related competencies (KRIVET, 2020; KEDI, 2021). According to an outcome evaluation conducted by the Korea Research Institute for Vocational Education and Training (KRIVET), students who participated in the University Job Center programs demonstrated statistically significantly higher levels of career decision-making and job preparation behavior indices than their non-participating counterparts. In particular, early intervention at the lower-division level was found to have positive effects on enhancing students' understanding of occupational roles and clarifying their career goals (KRIVET, 2020). These findings suggest that a continuous and institutionally embedded career and employment support system within universities can contribute not only to short-term employment outcomes but also to the medium- and long-term development of students' employability competencies.

In a policy research report by the Korean Educational Development Institute (KEDI), extracurricular employment support programs, major-linked job experience activities, internships, and industry-partnered programs were found to positively influence students' perceptions of core vocational competencies and their ability to apply major-related knowledge and skills (KEDI, 2021). Notably, students who engaged in employment support programs integrated with major courses tended to report significantly higher

perceptions of major–labor market alignment and greater confidence in performing job-related tasks.

Similar findings have also been confirmed in empirical studies conducted at the individual university level. Students with experience participating in employment support programs reported higher mean levels of job information-seeking competence, career planning capability, and job-search self-efficacy than those who did not participate, and these effects were more clearly observed in competency-related variables than in simple employment rate outcomes (Choi, 2020; Nam & Choi, 2022; Kim & Oh, 2022; Lim, 2018). This suggests that evaluations of university-based employment initiatives should move beyond short-term employment outcomes and instead place greater emphasis on changes in students' employability competencies and career preparedness.

Taken together, university-based employment and competency development initiatives in South Korea have been shown to contribute empirically to improvements in students' job preparation behaviors, career clarity, and perceived job- and major-related competencies. In particular, the integration of the university as a learning environment with institutionalized employment support functions appears to serve as a key mechanism for enhancing the effectiveness of employability development.

At N University in the Chungnam region, a regionally tailored workforce development initiative implemented a 480-hour training program titled "Immersive AR/VR Content Production Training Using Unity" from June to October 2025. This program was offered as part of the Regional Industry-Tailored Human Resource Development Project, which aims to cultivate job-ready talent aligned with local industry needs through intensive, practice-oriented training.

The Regional Industry-Tailored Human Resource Development Project is administered by Regional Human Resources Development Councils (RHRDCs) across each region and implemented through a range of training providers, including the Human Resource Development Institute of the Korea Chamber of Commerce and Industry and Korea Polytechnics. The project is supported by the Ministry of Employment and Labor and the Human Resources Development Service of Korea (HRD Korea) and offers customized vocational training programs for job seekers—such as youth and career-interrupted women—based on the workforce demands of local industries and employers. Information on available training courses can typically be accessed through the websites of the relevant regional councils or affiliated institutions.

This training program was designed to cultivate practice-oriented professionals equipped with Unity-based AR/VR content development skills in response to the rapid growth of the immersive content industry driven by the Fourth Industrial Revolution and ongoing digital transformation. The program targeted 20 university graduates who were unemployed or students expected to graduate soon, and provided participants with dormitory accommodation and lunch throughout the training period. In

addition, trainees received a monthly training allowance of KRW 200,000 to support their participation.

The core curriculum consisted of both theoretical instruction and hands-on practice in 2D and 3D design, immersive content production, and foundational UX/UI design. It also included training in key design and content development tools and software, such as Photoshop, Blender, Unity, and Unreal Engine. In addition, the program emphasized practice-oriented learning through project-based training, including VR/AR projects and game development projects. The targeted employment fields encompassed a wide range of sectors within the digital content industry, including gaming, design, animation, software development, and immersive content production. At N University, this program was implemented in connection with existing XR-related courses, including XR Studio, 3D Content Production, VR/AR Storytelling, and XR Game Content.

The present study aims to evaluate the effectiveness of the “Immersive AR/VR Content Production Training Program Using Unity” offered at N University by examining the extent to which the program enhanced students’ major-related competencies in XR/VR and by analyzing their overall satisfaction with the program. This research is meaningful in that it provides empirical evidence regarding the effectiveness of intensive training programs in strengthening major competencies at small- and medium-sized regional universities, thereby offering a rationale for expanding and institutionalizing such programs in the future.

To achieve the purpose of this study, the specific research questions are as follows.

First, this study examines the overall levels of participants’ AR/VR major-related competencies, AI competencies, and program satisfaction.

Second, it investigates differences in AR/VR major-related competencies and program satisfaction according to participants’ gender and academic year.

Third, it tests whether participants’ AR/VR major-related competencies and AI competencies significantly improved after completing the program compared to their pre-program levels.

Fourth, it analyzes participants’ perspectives on their motivations for program participation and their perceptions of the program’s effectiveness.

II. Research Methods

1. Participants

The participants of this study were students enrolled in a Unity-based AR/VR content development program at a university located in the Chungcheong region of South Korea. The program was conducted from June to October 2025

and consisted of a total of 480 instructional hours. After receiving an explanation of the study purpose and procedures, students who voluntarily agreed to participate completed an online survey. A total of 18 questionnaires were distributed and collected, and three participants were additionally selected for in-depth interviews.

Table 1 presents the socio-demographic characteristics of the survey respondents (N=18). The sample included an equal number of male and female students, with 9 males (50.0%) and 9 females (50.0%). In terms of academic year, 2 students (11.1%) were in their second year, 11 students (61.1%) were in their third year, and 5 students (27.8%) were in their fourth year. Overall, the participants were predominantly upper-level undergraduate students, with the majority being third-year students.

Table 2 summarizes the general information of the interviewees (n=3). Interviewee A was a female third-year student aged 21, majoring in Virtual Reality. Interviewee B was a male third-year student aged 23, also majoring in Virtual Reality. Interviewee C was a female fourth-year student aged 22, with the same major. All interview participants were drawn from the same program context, enabling a focused exploration of students' learning experiences in Unity-based AR/VR content development.

Table 1. Socio-demographic Characteristics of the Participants (N=18)

Variables	Classification	Frequency	Per Cent
Gender	Male	9	50.0
	Female	9	50.0
School year	2nd	2	11.1
	3rd	11	61.1
	4th	5	27.8

Table 2. General Information of Interviewee

Name	Gender	School Year	Age	Major
A	Female	3	21	Virtual Reality
B	Male	3	23	Virtual Reality
C	Female	4	22	Virtual Reality

2. Research Instruments

In this study, the effectiveness of the program was examined using pre–post measures of AR/VR major competency and AI competency, and post-program educational satisfaction was additionally assessed. All items were rated on a five-point Likert scale (1=strongly disagree to 5=strongly agree), with higher scores indicating higher competency or satisfaction.

AR/VR content development competency was developed based on the department's competency framework and the skill requirements suggested by Verma et al. (2021). Two major professors and two education professors reviewed and refined the items through two to three rounds of revision. The scale consisted of four subdomains—technical and practical competence (α=.83), creative problem-solving competence (α=.93), collaboration and project execution competence (α=.92), and self-directed learning and professional attitude competence (α=.89)—with four items per subdomain (16 items total). A sample item was: "I can utilize basic Unity functions (e.g., object placement, physics engine, and UI)."

AI competency was constructed based on Baek (2025) and Oh (2025), comprising three subdomains: AI cognition (α=.84), AI emotion (α=.87), and AI behavior (α=.82). Each subdomain included four items (12 items total), and a sample item was: "I have a conceptual understanding of what artificial intelligence is."

Educational satisfaction was measured after the program using selected items from Kim (2015), covering contents (7 items, α=.88), instructors (4 items, α=.90), and facilities (4 items, α = .86). A sample item was: "I believe this training will be helpful in achieving my educational goals."

To further explore participants' motivations and perceived outcomes, one-on-one in-depth interviews were conducted once on October 29, 2025, with three volunteers. The two guiding questions were: "What motivated you to participate in this program?" and "What effects did you experience as a result of participating in this program?"

Table 3. Pre–Post Measurement Instruments

Period	Category	Sub-category	No. of Items	Cronbach's alpha	Sample Questions
Pre & Post test	AR/VR Content Development Competency	Technical & Practical Competence	4	.83	I can utilize basic Unity functions (e.g., object placement, physics engine, and UI).
		Creative Problem-Solving Competence	4	.93	I can plan content by considering user experience (UX).
		Collaboration & Project Execution Competence	4	.92	I can carry out collaborative tasks through effective communication with team members.
		Self-directed Learning & Professional Attitude Competence	4	.89	I can set my own learning goals, develop a plan, and follow through with it
	AI Competency	AI Cognition	4	.84	I have a conceptual understanding of what artificial intelligence is.
		AI Emotion	4	.87	I feel anticipation and interest in artificial intelligence.
		AI Behavior	4	.82	I can use artificial intelligence tools (e.g., chatbots and automated systems).
Post test	Educational Satisfaction	Contents	7	.88	I believe this training will be helpful in achieving my educational goals.
		Instructors	4	.90	The instructor demonstrated expertise and enthusiasm.
		Facilities	4	.86	The learning environment was suitable for the program.

3. Data Analysis

The collected data were analyzed using SPSS version 18.0.
First, frequency analysis was conducted to examine participants' general characteristics (grade level and gender). Descriptive statistics were also performed to identify the overall levels of AR/VR major competency, AI competency, and program satisfaction.
Second, independent samples t-tests and one-way ANOVA were conducted to examine differences in major competency, AI competency, and program satisfaction according to gender and grade level.
Third, to evaluate the effectiveness of the program, paired-samples t-tests were performed to compare participants' pre-test and post-test scores on major competency and AI competency.
Fourth, interview data collected to explore learners' motivations for participation, perceived program effects, strengths, and areas for improvement were analyzed using content analysis. For this analysis, the transcripts were repeatedly reviewed through multiple rounds of intensive reading (first, second, and third cycles), and the data were categorized into meaningful themes.

III. Research Results

1. Frequency and Descriptive Statistics of Major Variables

Table 4 presents the descriptive statistics of the major variables. For AR/VR Content Development Competency, the overall mean score was 4.09 (SD=0.61). Among the subdomains, Collaboration and Project Execution Competence showed the highest mean (M=4.31, SD=0.57), followed by Self-directed Learning and Professional Attitude Competence (M=4.25, SD=0.60), Creative Problem-Solving Competence (M = 4.02, SD = 0.68), and Technical and Practical Competence (M=3.79, SD=0.84).

Regarding AI Competency, the total mean was 4.16 (SD=0.44). Among its subdomains, AI Behavior recorded the highest mean (M=4.29, SD=0.75), followed by AI Cognition (M=4.20, SD=0.47) and AI Emotion (M=3.98, SD=0.46). For Educational Satisfaction, the overall mean score was 4.22 (SD=0.72). In particular, satisfaction with Facilities was the highest (M=4.26, SD=0.76), followed by Instructors (M=4.25, SD=0.75) and Contents (M=4.18, SD=0.73). Overall, participants reported relatively high levels of AR/VR competency, AI competency, and educational satisfaction, with mean scores above the midpoint across all domains.

Table 4. Descriptive Statistics of Major Variables (N=18)

Variables		N	Min.	Max.	Mean	SD
AR/VR Content Development Competency	Technical & Practical Competence	18	2.25	5.00	3.79	.84
	Creative Problem-Solving Competence	18	2.75	5.00	4.02	.68
	Collaboration & Project Execution Competence	18	3.25	5.00	4.31	.57
	Self-directed Learning & Professional Attitude Competence	18	3.00	5.00	4.25	.60
	Total	18	2.81	5.00	4.09	.61
AI Competency	AI Cognition	18	3.50	5.00	4.20	.47
	AI Emotion	18	3.25	5.00	3.98	.46
	AI Behavior	18	2.75	5.00	4.29	.75
	Total	18	3.33	4.83	4.16	.44
Educational Satisfaction	Contents	18	2.57	5.00	4.18	.73
	Instructors	18	3.00	5.00	4.25	.75
	Facilities	18	3.00	5.00	4.26	.76
	Total	18	2.83	5.00	4.22	.72

Table 4 Descriptive Statistics of Major Variables

2. Differences of Main Variables by School-year and Major

Table 5 presents differences in the main variables by school year (2nd–4th year). Overall, mean scores across AR/VR content development competency, AI competency, and educational satisfaction were relatively high for all grade levels. However, one-way ANOVA results indicated that none of the differences by school year were statistically significant across any subdomain or total score (all $p>.05$). These findings suggest that students' perceived competencies and program satisfaction were generally consistent regardless of grade level.

Table 5. Differences of main variables by school-year (N=18)

Classification			N	M	SD	F
AR/VR Content Development Competency	Technical & Practical Competence	2nd school-year	2	4.38	0.53	.598
		3rd school-year	11	3.68	0.95	
		4th school-year	5	3.80	0.74	
	Creative Problem-Solving Competence	2nd school-year(b)	2	3.88	0.53	.884
		3rd school-year(c)	11	4.00	0.84	
		4th school-year(d)	5	4.15	0.38	
	Collaboration & Project Execution Competence	2nd school-year	2	4.13	0.18	.725
		3rd school-year	11	4.41	0.71	
		4th school-year	5	4.20	0.27	
	Self-directed	2nd school-year	2	4.13	0.18	.849

Classification			N	M	SD	F
	Learning & Professional Attitude Competence	3rd school-year	11	4.32	0.77	
		4th school-year	5	4.15	0.14	
	Total	2nd school-year	2	4.13	0.09	
		3rd school-year	11	4.10	0.77	.995
		4th school-year	5	4.08	0.35	
AI Competency	AI Cognition	2nd school-year	2	4.13	0.18	
		3rd school-year	11	4.18	0.56	.884
		4th school-year	5	4.30	0.41	
	AI Emotion	2nd school-year	2	4.00	0.35	
		3rd school-year	11	4.02	0.45	.898
		4th school-year	5	3.90	0.60	
	AI Behavior	2nd school-year	2	4.50	0.71	
		3rd school-year	11	4.34	0.80	.783
		4th school-year	5	4.10	0.80	
	Total	2nd school-year	2	4.21	0.41	
		3rd school-year	11	4.18	0.46	.939
		4th school-year	5	4.10	0.50	
Educational Satisfaction	Contents	2nd school-year	2	4.29	0.20	
		3rd school-year	11	4.10	0.86	.868
		4th school-year	5	4.31	0.63	
	Instructors	2nd school-year	2	4.50	0.71	
		3rd school-year	11	4.05	0.85	.385
		4th school-year	5	4.60	0.49	
	Facilities	2nd school-year	2	4.50	0.71	
		3rd school-year	11	4.02	0.83	.244
		4th school-year	5	4.70	0.45	
	Total	2nd school-year	2	4.42	0.51	
		3rd school-year	11	4.07	0.83	.510
		4th school-year	5	4.51	0.50	

* p<.05 ** p<.01 *** p<.001

Table 6 presents gender differences in the main variables (N=18). Male students reported higher levels of AR/VR content development competency than female students, with statistically significant differences observed in Collaboration and Project Execution Competence (p<.01), Self-directed Learning and Professional Attitude Competence (p<.01), and the total AR/VR competency score (p<.05).

For AI competency, males also showed significantly higher scores in AI Behavior (p< .05) and the overall AI competency total (p<.05), whereas differences in AI Cognition and AI Emotion were not statistically significant.

In contrast, educational satisfaction did not significantly differ by gender across any subdomain or total score (all p>.05). Overall, the findings suggest that male students perceived stronger competency

development in several AR/VR and AI domains, while satisfaction with the program was comparable between genders.

Table 6. Differences of Main Variables by gender (N=18)

Classification			N	M	SD	t
AR/VR Content Development Competency	Technical & Practical Competence	Male	9	4.17	0.72	.058
		Female	9	3.42	0.84	
	Creative Problem-Solving Competence	Male	9	4.22	0.74	.240
		Female	9	3.83	0.60	
	Collaboration & Project Execution Competence	Male	9	4.67	0.52	.006**
		Female	9	3.97	0.40	
	Self-directed Learning & Professional Attitude Competence	Male	9	4.64	0.47	.003**
		Female	9	3.86	0.45	
	Total	Male	9	4.42	0.51	.019*
		Female	9	3.77	0.55	
AI Competency	AI Cognition	Male	9	4.36	0.49	.184
		Female	9	4.06	0.45	
	AI Emotion	Male	9	4.17	0.40	.101
		Female	9	3.81	0.48	
	AI Behavior	Male	9	4.64	0.49	.048*
		Female	9	3.94	0.85	
	Total	Male	9	4.39	0.31	.025*
		Female	9	3.94	0.46	
Educational Satisfaction	Contents	Male	9	4.48	0.58	.092
		Female	9	3.89	0.79	
	Instructors	Male	9	4.43	0.75	.344
		Female	9	4.08	0.77	
	Facilities	Male	9	4.39	0.75	.505
		Female	9	4.14	0.80	
	Total	Male	9	4.44	0.65	.228
		Female	9	4.02	0.76	

* p<.05 ** p<.01 *** p<.001

3. Program Effects: Pre & Post-test

Paired-samples t-tests were conducted to examine pre–post changes in AR/VR content development competency and AI competency (N=18). For AR/VR competency, a significant improvement was found

only in Technical and Practical Competence, which increased from M=2.97 (SD=0.82) to M = 3.79 (SD=0.85) (p<.01). The total AR/VR competency score showed an upward trend from M = 3.59 (SD=0.65) to M = 4.10 (SD=0.61), but the change was not statistically significant (p = .072).

For AI competency, significant increases were observed in AI Cognition (p<.05), AI Emotion (p<.05), and the overall AI competency total (p<.05). In contrast, AI Behavior did not show a statistically significant change (p=.194). Overall, the results indicate that the program was effective in enhancing participants' technical AR/VR skills and improving cognitive and affective dimensions of AI competency.

Table 7. Effect of the program: differences of pre-test & post-test

Variables		N	Pre-test		Post-test		t
			Mean	SD	Mean	SD	
AR/VR Content Development Competency	Technical & Practical Competence	18	2.97	0.82	3.79	0.85	.006**
	Creative Problem-Solving Competence	18	3.58	0.83	4.03	0.69	.088
	Collaboration & Project Execution Competence	18	3.94	0.82	4.32	0.57	.121
	Self-directed Learning & Professional Attitude Competence	18	3.86	0.65	4.25	0.60	.072
	Total	18	3.59	0.65	4.10	0.61	.022*
AI Competency	AI Cognition	18	3.74	0.75	4.21	0.48	.031*
	AI Emotion	18	3.53	0.57	3.99	0.47	.013*
	AI Behavior	18	3.97	0.69	4.29	0.76	.194
	Total	18	3.75	0.56	4.16	0.44	.018*

*p<.05 ** p<.01 *** p<.001

4. Qualitative Data Analysis

The data collected through in-depth interviews in this study were analyzed by applying two predetermined categories, and two subcategories were derived under each category (Table 8).

Table 8. Category & Sub-category

Category	Questions	Sub-categories
Motivation for Participation	What motivated you to participate in this program?	Opportunities for employment Collaborative project
Program Effects	What were the effects of participating in this program?	Improvement in major-related competencies Enhanced collaboration skills and adaptation to university life

1) Motivation for Participation

(a) Opportunities for Employment

As students progressed into higher academic years, they perceived the improvement of practical, major-related competencies as increasingly important for employment preparation. In particular, they reported that they decided to participate because this training opportunity was linked to an internship program that could provide direct career-related experience. In addition, participants expected that intensive engagement during the vacation period would help them enhance their skills and strengthen their competitiveness in the job market.

> "I decided to participate because I thought I could improve my skills by focusing intensively on the work during the vacation." (Student A)

> "I participated because it is an employment-linked program and provides an opportunity for an internship." (Student B)

(b) Collaborative Project

Participants also expressed strong motivation to engage in collaborative projects with peers, including both senior and junior students. They expected that co-working and project-based collaboration would contribute to improving the overall quality of their work, particularly in relation to capstone or graduation projects. Moreover, they described anticipation and enjoyment associated with working together as a meaningful aspect of the program experience.

> "I thought working with my peers would improve the quality of my graduation project." (Student B)

> "Working on a project with seniors and juniors makes me look forward to the experience, because the collaboration itself can be enjoyable." (Student C)

2) Perceived Program Effects

(a) Improvement in Major Competency and Portfolio Development

Participants reported that the program enabled them to engage in tasks that would have been difficult to complete independently. They also noted that participation in competitions became possible through the program, and that they were able to receive intensive guidance and support from major faculty members. In particular, students emphasized that producing employment-relevant outcomes through the program was beneficial, as it allowed them to build and strengthen their portfolios for future career preparation.

> "I was able to learn things I didn't know and participate in a competition." (Student B)

"It was good because my skills improved and I could build my portfolio." (Student A)

(b) Enhancement of Collaboration and Adaptation to University Life

Participants also described positive changes in collaboration and overall adjustment to university life. They indicated that the special program created an environment in which it was easier to ask questions during class, which supported their skill development. In addition, students reported that the program provided valuable opportunities to build closer relationships with professors and to develop social connections with senior and junior students through collaborative projects. Some participants expressed a strong intention to recommend the program to younger students.

"By working on the project in the evening, I stayed on campus longer and became more adapted to university life." (Student A)

"It was nice to spend time together with my friends." (Student C) "I would strongly recommend it to juniors." (Student B)

IV. Discussion

This study examined the effectiveness of a Unity-based AR/VR content development training program implemented at a regional university, focusing on changes in students' AR/VR major-related competencies, AI competencies, and program satisfaction. By integrating quantitative outcomes with qualitative insights, the findings provide a nuanced understanding of how intensive, practice-oriented training contributes to competency development in higher education.

First, the results demonstrated a significant improvement in students' technical and practical AR/VR competence following program participation. This finding aligns with prior research emphasizing the effectiveness of immersive and hands-on learning environments in fostering procedural knowledge and technical skill acquisition. Systematic reviews and meta-analyses have consistently shown that AR/VR-based instruction enhances learning outcomes when it is embedded in authentic, task-oriented activities rather than used as a supplementary visualization tool (Radianti et al., 2020; Makransky et al., 2019). The present study extends this body of literature by providing empirical evidence that such benefits can be realized within a regional university context through an intensive Unity-based training model. This suggests that immersive, project-centered AR/VR education can function as an effective mechanism for strengthening major-related competencies even in institutions with relatively limited resources.

Second, among the AR/VR competency subdomains, collaboration and project execution competence showed the highest mean score, followed by self-directed learning and professional attitude competence. These findings are consistent with prior studies on project-based and problem-based learning, which highlight collaborative problem-solving, shared responsibility, and iterative project cycles as key drivers of higher-order skill development (Bell, 2010; Hmelo-Silver, 2004). The program's emphasis on team-based projects and sustained production tasks likely created conditions that promoted active engagement, peer learning, and mutual accountability. Moreover, the relatively high level of self-directed learning competence corresponds with Zimmerman's (2002) model of self-regulated learning, suggesting that extended, autonomy-supportive learning environments can enhance learners' capacity to set goals, manage learning processes, and adopt professional attitudes toward their work. These findings indicate that competency development in AR/VR education is closely linked to instructional designs that foreground collaboration and learner agency.

Third, the results related to AI competency revealed a differentiated pattern across subdomains. While significant improvements were observed in AI cognition and AI emotion, AI behavior did not show a statistically significant increase. This pattern can be interpreted through existing conceptualizations of AI literacy, which describe it as a multi-layered construct progressing from conceptual understanding and affective engagement to applied behavioral competence (Long & Magerko, 2020; Ng et al., 2021). From this perspective, the findings suggest that the program was effective in enhancing students' awareness of AI concepts and their interest in AI-related technologies, but that these gains did not fully translate into behavioral application. Prior research on digital and 21st-century skills emphasizes that behavioral competence typically requires repeated, task-specific practice and explicit opportunities for application (van Laar et al., 2017). Therefore, future iterations of AR/VR training programs may benefit from more deliberately embedding AI tool utilization—such as AI-assisted design, content optimization, or debugging—into project deliverables to facilitate the transition from cognitive and affective gains to practical AI use.

Fourth, gender differences were observed in several AR/VR and AI competency domains, with male students reporting higher levels of collaboration/project execution competence, self-directed learning and professional attitude competence, AI behavior, and overall AI competency. These findings are consistent with previous studies indicating that male students often report higher self-efficacy and more frequent informal engagement with digital technologies, which can influence perceived competence in technical and collaborative contexts (Cooper, 2006; Scherer et al., 2019). Importantly, however, no significant gender differences were found in educational satisfaction. This suggests that while perceptions of competency development differed, the overall learning environment and program value were experienced similarly by male and female students. This divergence underscores the importance of distinguishing between perceived competence and satisfaction, and highlights the need for instructional strategies that actively promote equitable participation and skill development—particularly in team-based, technology-intensive learning environments.

Taken together, the findings underscore the educational value of intensive, practice-oriented Unity-based AR/VR training programs for enhancing university students' competencies and learning experiences. By situating the results within relevant literature on immersive learning, project-based education, AI literacy, and gender differences in technology use, this study contributes to a deeper understanding of how competency development occurs in emerging technology domains. In particular, the results suggest that such programs can serve not only as skill-building interventions but also as structured learning environments that foster collaboration, self-directed learning, and professional identity formation—outcomes that are especially meaningful for regional universities seeking scalable and context-sensitive models of competency-based education.

V. Conclusions

This study evaluated the effectiveness of a Unity-based AR/VR content development training program by examining students' AR/VR major-related competencies, AI competencies, and program satisfaction. Overall, participants reported relatively high levels of AR/VR competency, AI competency, and satisfaction after completing the program, indicating that the training was perceived as meaningful and relevant to their learning and career preparation.

The findings also showed that competency levels did not significantly differ by academic year, while several gender differences were observed in AR/VR and AI competency domains. Pre–post comparisons demonstrated significant improvements in technical and practical AR/VR competence as well as overall

AI competency, particularly in cognitive and affective dimensions. In-depth interviews further supported these results by highlighting employment-related opportunities and collaborative projects as key participation motives, and by identifying portfolio development, enhanced collaboration, and improved adaptation to university life as major perceived outcomes. Taken together, the results provide empirical support for the value of intensive, practice-oriented Unity-based training programs in strengthening university students' competencies and learning experiences.

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