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How Student-Led Collaborative Metaverse World Creation Fosters Information Literacy and Intercultural Competence: A Quantitative Analysis of a Synchronous International Virtual Exchange

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Abstract: This study investigates how student-led Metaverse World creation, conducted as part of a synchronous international virtual exchange (VE), fosters information literacy (IL) and intercultural competence (IC) among university students. Eighteen Japanese students collaborated with international and overseas students in multinational teams to design and present culturally themed Metaverse environments using Unity, VRChat, and a Metaverse World Creation Package. Quantitative analyses of pre- and post-program surveys revealed significant gains in digital fluency, immersive communication, and cultural learning strategies. Notably, participants enhanced their confidence and sensitivity in intercultural interactions while acquiring XR design skills and operating head-mounted displays (HMDs) within 15 weeks, despite minimal prior experience. Survey responses also indicated high motivation and positive perceptions of the technology's educational value. These findings highlight the potential of immersive, co-creative environments to promote 21st century skills. By shifting learners from passive recipients to active creators, the program demonstrates a scalable model for integrating XR into international education. This study contributes to the fields of educational technology and Computer-Supported Collaborative Learning (CSCL) by evidencing the pedagogical benefits of student agency and intercultural engagement within the Metaverse.

Keywords: Metaverse in Education, International Virtual Exchange (VE), Information Literacy, Intercultural Competence, XR-Based Learning, Computer-Supported Collaborative Learning (CSCL)

1. Introduction

In the context of global education, both information literacy (IL) and intercultural competence (IC) are recognized as essential twenty-first century skills (Partnership for 21st Century Skills, 2009). Telecollaborative projects provide students with opportunities to develop IC by interacting with individuals from diverse cultural backgrounds in a digital learning environment (Çiftçi, 2016).

IL involves not only the ability to locate and evaluate information, but also the ability to use digital tools for creative production and effective communication. IC encompasses the knowledge, attitudes, and behaviors that enable meaningful and respectful engagement with culturally diverse peers. As global interconnectedness deepens, the ability to navigate digital and intercultural spaces simultaneously is becoming increasingly crucial in higher education.

In response to these demands, the Cabinet Secretariat's Council for Creating the Future of Education launched the J-MIRAI initiative to promote the internationalization of education through digital means, aiming to expand online international exchange programs nationwide (Cabinet Secretariat, Council for Creating the Future of Education, 2023). National strategies also emphasize the educational use of Metaverse technologies for future economic development. In line with these policies, our project investigates the potential of

XR-based virtual exchange programs as a scalable and innovative approach to fostering both IL and IC in global education (Hayashi, 2024).

Recent advancements in Extended Reality (XR) and Metaverse technologies have introduced new opportunities for immersive, participatory learning that transcends physical and cultural boundaries. While previous studies, such as Shadiev et al. (2023), have explored the impact of asynchronous VR-based bilateral cultural exchanges, few have examined real-time, multinational, student-generated Metaverse learning environments. To address this gap, the present study investigates a synchronous international collaboration project involving Japanese university students, international students, and overseas participants, designed to promote experiential and co-creative learning.

Through the co-creation of culturally themed Metaverse Worlds using Unity and a custom-developed Metaverse World Creation Package (MWCP), students engaged in real-time intercultural collaboration, presentation, and reflection. This study aims to explore how such immersive, student-led activities foster the development of 21st-century skills, with particular attention to IL, IC, and learners' perceptions of immersive technologies. The following research questions guide this study:

1. To what extent did the learning activity promote the development of Japanese students' information literacy (IL), particularly in terms of Metaverse World creation, head-mounted display (HMD) operation, and immersive communication?
2. To what extent did the activity facilitate the development of Japanese students' intercultural competence (IC), specifically in terms of their knowledge and sensitivity?
3. After participating, what were Japanese students' perceptions of Metaverse World creation technology and its role in international collaborative learning?

2. Literature Review

2.1 Information Literacy in XR-Enhanced Learning

IL, a foundational 21st Century Skills encompassing abilities to access, evaluate, create, and communicate information with digital tools (Shadiev et al., 2023), expands its definition in education with the prominence of XR technologies to include immersive communication and creative production in digital environments (Rauschnabel et al., 2022). While recent studies explore XR's potential in developing technological fluency, design thinking, and storytelling (Bower et al., 2020), research on student-led Metaverse World creation using advanced tools like Unity or VRChat remains limited.

In this study, IL is conceptualized, following Shadiev et al. (2023, p. 2510), as primarily "the individual's ability to locate, evaluate and use information effectively" and to "effectively communicate information through different media on various digital platforms." This is further expanded to include "learners' ability to use digital tools when collaborating with others to share information, to create media products, and to perform and complete assigned tasks utilizing digital tools effectively."

Accordingly, we interpret IL as a multidimensional competency of critical evaluation and creative expression via digital technologies. This perspective is particularly relevant in student-led Metaverse World production, where learners must combine technical, collaborative, and communicative skills.

2.2 Intercultural Competence

IC refers to the ability to interact effectively across cultures, encompassing cognitive (knowledge), affective (sensitivity), and behavioral dimensions. In this study, we adopt the conceptual framework of IC as defined by Shadiev et al. (2023), drawing on Chen and Starosta (1997) and Deardorff (2006). IC is understood as "the ability of individuals to function effectively across cultures, to think and act appropriately, and to communicate and work with other individuals from different cultural backgrounds based on their intercultural knowledge and sensitivity" (Shadiev et al., 2023, p. 2510).

According to this framework, intercultural knowledge refers to cultural information acquired through communication and exchange with individuals from other cultures, while intercultural sensitivity is defined as "an individual's ability to develop a positive emotion towards understanding and appreciating cultural differences that promotes appropriate and effective behavior in intercultural communication" (Chen & Starosta, 1997, p. 5).

This two-dimensional model provides a foundation for assessing students' development in cross-cultural competence, as applied in our study through pre- and post-surveys adapted from Shadiev et al. (2023).

2.3 Educational Use of the Metaverse in International Collaborative Contexts

In higher education, Virtual Exchange (VE) and Collaborative Online International Learning (COIL) offer practical alternatives to physical relocation for fostering intercultural skills. O'Dowd (2018) defines VE as sustained, educator-facilitated online intercultural collaboration between students in different cultural contexts.

Prior research (e.g., Shadiev et al., 2023) has shown that VR-based cultural exchanges can enhance both IL and IC. In addition, recent reviews highlight the Metaverse as an emerging learning ecology with transformative potential for education (Mystakidis, 2022). While metaverse platforms in education have traditionally been implemented through instructor- or institution-led initiatives, an increasing number of projects are now being co-created by students. These cases illustrate the growing pedagogical potential of metaverse platforms, but most serve primarily as programmatic showcases or isolated experiential learning activities without systematic assessment.

Unlike teacher-led programs where instructors design the content and guide interactions, this project adopted a student-led approach in which learners assumed responsibility for the design, content creation, and presentation of culturally themed Metaverse Worlds. This shift placed students in active agentive roles, promoting ownership of learning, intercultural negotiation, and digital creativity throughout the process.

Few educational practices exist in which students independently create Metaverse Worlds and deliver real-time, multinational presentations aimed at enhancing their peers' IC. Furthermore, empirical research measuring the learning outcomes of such student-led, immersive, synchronous intercultural activities remains limited. This study aims to fill this research gap by providing evidence of the educational impact of student-generated Metaverse environments in global collaborative learning contexts.

3. Methods

3.1 Participants and Group Composition

The program engaged 34 students from 10 countries across Asia, Africa, Europe, and North America. The participants included 18 Japanese students, 8 international students on-site in Japan, and 8 overseas students from partner institutions who joined remotely via videoconferencing tools and the Metaverse. Based on their language preferences (English or Japanese), students were divided into four groups, each with diverse national and linguistic backgrounds. Each group included students from 4 to 5 different countries and was further divided into three smaller teams. Every team was structured to include at least one Japanese student together with one international or overseas student to ensure cross-cultural collaboration. Many participants had little to no prior XR experience.

3.2 Learning Activity Overview and Instructional Support and Tools

Over a 15-week semester, students were organized into multinational teams to collaboratively create culturally themed Metaverse Worlds. Each team selected a subtopic under a shared group theme and worked together to prepare their presentation. Within their groups, teams then rehearsed their presentations and engaged in post-presentation discussions. The process concluded with a whole class sharing session. This structure clarified the distinct roles of teams and groups, fostering intercultural understanding, mutual engagement, and reduced isolation while offering more opportunities for active participation.

Real-time collaboration, discussions and presentations were conducted in VRChat (a social VR platform featuring user-generated 3D worlds; content is built in Unity and experienced on desktop or in VR). Discord served as both a real-time and asynchronous communication hub, enabling students to exchange messages, voice chat, and share files across different time zones. The creation process was supported by Unity, VRChat Creator Companion (the official tool for creating Unity projects for VRChat), the beginner-friendly MWCP tool (Hayashi et al., 2025), and GenAI.

Instructional sessions, tutorial slides, and teaching assistant (TA) support were provided for both VRChat and Unity. MWCP enabled students with no prior experience to build interactive environments through drag-and-drop functions, making Metaverse world creation accessible. While most participants on-site used HMDs during final presentations for increased immersion, some chose desktop interfaces due to motion sickness.

3.3 Data Collection and Analysis

To assess learning outcomes, we adapted a structured questionnaire framework from Shadiev et al. (2023) aligned with the course's learning goals. Key competencies—IL, IC—were sorted into specific micro-skills, which were assessed via pre- and post-surveys using a five-point Likert scale. Quantitative data was analyzed using paired samples t-tests to examine changes in students' responses before and after the course. Internal consistency was evaluated using Cronbach's α, with all domains exceeding 0.7, indicating acceptable reliability overall. Ethical approval (Tohoku University) and informed consent were obtained.

To ensure a coherent and statistically robust analysis, this study focuses on the 18 Japanese students. Comparing them with the smaller group of international students, who had significant prior study-abroad experience, was deemed problematic due to different starting points and insufficient sample sizes for subgroup analysis. This focus aligns with Japanese educational policy priorities such as the J-MIRAI initiative and allows for a meaningful contribution to fostering global competencies among this specific cohort.

4. Results

4.1 Information Literacy Development (Results for RQ1)

To address Research Question 1 (RQ1), a pre- and post-survey was conducted among Japanese university students (N = 18) to evaluate changes in their IL across three domains: (1) use of Metaverse Worlds, (2) creation of Metaverse Worlds, and (3) operation of HMDs. Sixteen students used HMDs, while those who experienced motion sickness opted not to use them. Therefore, only Table 3 reports results based on N = 16. As the number of valid responses met the general threshold suggested by Creswell (2018), statistical analysis was performed using paired samples t-tests.

All domains showed statistically significant gains. As shown in Table 1, the average score for Metaverse World use (Items 1–16) increased from 2.01 (SD = 0.51) to 4.67 (SD = 0.10). Table 2 presents the results for world creation using Unity and VCC (Items 17–28), where the average score rose from 1.62 (SD = 0.13) to 4.38 (SD = 0.23). As shown in Table 3, the average score for HMD operation (Items 29–39) improved from 1.31 (SD = 0.12) to 4.47 (SD = 0.17). These results suggest that the activity effectively enhanced students' operational and creative digital literacy.

Table 1. *Pre- and Post-Test Results for Basic Metaverse Skills*

#	Item	Before		After		Results	
		M	*SD*	*M*	*SD*	*t*	*p*
1	I know how to run Metaverse application on PC.	1.61	1.037	4.78	0.428	12.234	< .001
2	I know how to enter a Metaverse World.	1.39	0.850	4.78	0.428	14.693	< .001
3	I know how to send Friend Requests.	1.44	0.922	4.83	0.383	15.689	< .001
4	I know how to enter a World that my Friends are in.	1.33	0.840	4.83	0.383	17.317	< .001
5	I know how to teleport to another room within the same World.	1.50	0.924	4.78	0.428	15.542	< .001
6	I know how to move around within the Metaverse World.	1.89	1.231	4.83	0.383	9.923	< .001
7	I know how to turn on my PC microphone and talk within the Metaverse World.	3.11	1.491	4.78	0.428	4.610	< .001
8	I know how to identify who is speaking within the Metaverse World.	1.67	1.138	4.78	0.428	11.662	< .001
9	I know how to react using the Metaverse World Reaction feature.	1.72	1.179	4.78	0.428	11.159	< .001
10	I know how to sit in a chair within the Metaverse World.	1.61	1.037	4.72	0.461	11.662	< .001
11	I know how to use assets that amplifies my voice to present within the Metaverse World. (holding a microphone for the metaverse, standing on a podium, etc.)	1.39	0.850	4.67	0.485	14.512	< .001
12	I know how to move to another World through a Portal placed in the World I am currently in.	2.17	1.581	4.78	0.428	7.197	< .001
13	I know how to operate gimmicks within the Metaverse World.	1.83	1.043	4.61	0.608	10.576	< .001
14	I know how to enter a World via a Metaverse application website link.	2.22	1.437	4.56	0.616	7.000	< .001
15	I know how to operate presentation slides within the Metaverse World.	1.39	0.850	4.50	0.707	12.237	< .001
16	I know how to stream videos within the Metaverse World.	1.39	0.850	4.00	1.188	7.583	< .001
	Average (1-16)	1.73	0.813	4.69	0.390	14.655	< .001

Table 2. *Pre- and Post-Test Results for Metaverse World Creation Skills.*

#	Item	Before		After		Results	
		M	*SD*	*M*	*SD*	*t*	*p*
17	I know how to import a Metaverse world package.	1.67	1.085	4.33	0.767	9.522	< .001
18	I know the basics of operating a Metaverse World creation application and the main user interface (UI). (Unity)	1.61	0.916	4.39	0.778	11.115	< .001
19	I know how to import objects.	1.67	0.907	4.56	0.616	10.829	< .001
20	I know how to change the size and rotation of an object.	1.61	1.037	4.44	0.784	9.284	< .001
21	I know how to move objects to my desired location.	1.61	1.037	4.61	0.608	9.918	< .001
22	I know how to duplicate or delete objects.	1.61	1.037	4.61	0.608	9.918	< .001
23	I know how to export the world I have created as a package so I can send it to my teachers and classmates.	1.56	0.922	4.22	0.808	9.945	< .001
24	I know how to place presentation slides, images, and other files in the world.	1.39	0.850	4.28	0.826	10.363	< .001
25	I know how to view the contents of a World file (Scene) created by a classmate using a Metaverse creation application.	1.44	0.856	4.17	0.985	9.410	< .001
26	I know how to upload the world I have created to a Metaverse application.	1.39	0.850	4.22	0.808	10.449	< .001
27	I know how to change the design of floors and walls.	1.50	0.924	4.06	1.056	8.693	< .001
28	I know how to set up gimmicks.	1.39	0.850	3.72	1.364	6.153	< .001
	Average (17-28)	1.54	0.858	4.30	0.712	11.035	< .001

Table 3. *Pre- and Post-Test Results for HMD Usage Skills*

#	Item	Before		After		Results	
		M	*SD*	*M*	*SD*	*t*	*p*
29	I know how to run Metaverse application on the HMD.	1.13	0.342	4.38	0.885	12.211	< .001
30	I know how to enter a Metaverse World while wearing the HMD.	1.13	0.342	4.50	0.632	18.781	< .001
31	I know how to move around within the Metaverse World while wearing the HMD.	1.13	0.342	4.50	0.516	21.804	< .001
32	I know how to turn on my microphone on the HMD and talk within the Metaverse World.	1.25	0.577	4.38	0.885	11.491	< .001
33	I know how to mute my microphone on the HMD.	1.38	0.719	4.50	0.816	11.491	< .001
34	I know how to identify who is speaking within the Metaverse World while wearing the HMD.	1.38	0.806	4.56	0.814	11.500	< .001
35	I know how to react using the Metaverse World Reaction feature while wearing the HMD.	1.38	0.806	4.44	0.629	13.190	< .001
36	I know how to sit in a chair within the Metaverse World while wearing the HMD.	1.19	0.403	4.50	0.632	15.174	< .001
37	I know how to move to another World through a Portal placed in the World I am currently in while wearing the HMD.	1.19	0.403	4.63	0.500	18.902	< .001
38	I know how to operate gimmicks within the Metaverse World while wearing the HMD.	1.19	0.403	4.56	0.629	16.745	< .001
39	I know how to use my hand-held controllers or head to react nonverbally (clapping, nodding, etc.) without using the Reaction feature.	1.50	0.894	4.50	0.816	9.909	< .001
	Average (29-39)	1.26	0.423	4.49	0.572	17.334	< .001

4.2 Intercultural Competence Development (Results for RQ2)

To address Research Question 2 (RQ2), a pre- and post-survey based on Shadiev et al. (2023) was administered to assess changes in students' intercultural knowledge and sensitivity. Paired samples t-tests were conducted for each item.

Intercultural knowledge improved from an average of 3.39 (*SD* = 0.75) to 4.38 (*SD* = 0.51), with all 10 items showing statistically significant increases. The most prominent gains were in learning strategies and cultural stress management. Intercultural sensitivity increased from 3.90 (*SD* = 0.41) to 4.05 (*SD* = 0.41). Subdomains, such as "interaction confidence" and "interaction engagement" showed strong gains, while other areas, such as "respect for cultural differences" and "intercultural attentiveness" remained stable. The combined average across all 34 items rose from 3.75 (*SD* = 0.48) to 4.16 (*SD* = 0.36), confirming positive development in students' IC ($p < .001$).

Table 4. *Pre- and Post-Test Results for Average Intercultural Competence*

#	Domain	Before		After		Results	
		M	*SD*	*M*	*SD*	*t*	*p*
1	Intercultural competence (Average:2-3)	3.75	0.475	4.16	0.395	5.176	< .001
2	Intercultural knowledge	3.39	0.751	4.38	0.511	6.013	< .001
3	Intercultural sensitivity (Average:4-8)	3.90	0.410	4.05	0.410	2.456	0.025
4	Interaction engagement	4.24	0.413	4.43	0.462	1.930	0.070
5	Respect for cultural differences	4.68	0.316	4.61	0.253	-0.875	0.394
6	Interaction confindence	2.91	0.749	3.32	0.777	3.297	0.004
7	Interaction enjoyment	3.28	0.909	3.33	0.792	0.419	0.681
8	Interaction attentiveness	3.85	0.698	4.07	0.479	1.799	0.090

Note: All survey items were adapted from Shadiev et al. (2023). Due to space limitations, only the average scores for each category are presented here.

4.3 Participants' Perceptions of Metaverse World Technology (Results for RQ3)

To address Research Question 3 (RQ3), a post-survey (Items 40–51) assessed Japanese students' perceptions of the Metaverse World production technology. As these items were administered only after the course, descriptive statistics were reported without comparison.

Students responded positively overall, with an average score of 4.13 (*SD* = 0.32). High satisfaction was reported for enjoyment and motivation (e.g., Item 46, M = 4.61, *SD* = 0.50). Students also expressed confidence in the technology's educational value (Item 48, M = 4.06, *SD* = 1.00) and immersive quality (Item 50, M = 4.28, *SD* = 0.83). These results indicate favorable reception of the technology and potential to support future VE initiatives.

Table 5. *Post-Survey Results for Perceptions of Metaverse World Creation Technology*

#	Item	M	SD
40	I want to continue using Metaverse World production technology.	4.11	0.900
41	I prefer Metaverse World production technology to other tools.	3.67	0.970
42	If I can, I will continue to use Metaverse World production technology.	4.11	0.832
	Continuance intention (40-42)	3.96	0.831
43	I am happy with the decision to use Metaverse World presentation.	4.33	0.686
44	I chose to use this technology wisely.	4.17	0.786
45	I am happy with my choice to use Metaverse World presentation.	4.39	0.502
46	I am very pleased with the experience of using this technology.	4.61	0.502
	Satisfaction (43-46)	4.38	0.570
47	Using Metaverse World presentation to conduct cross-cultural learning meets my expectation.	4.39	0.608
48	This technology has given me all the information and tools I need to learn across cultures.	4.06	0.998
49	My experience of cross-cultural learning through the use of Metaverse World did not meet my expectations.	4.28	0.461
50	The sense of presence provided by Metaverse World presentation meets my expectations.	4.28	0.826
51	I think Metaverse World presentation achieves the level of functionality I want.	3.89	0.963
	Confrmation (47-51)	4.18	0.609

5. Discussion

5.1 Information Literacy (Discussion for RQ1)

Japanese students demonstrated statistically significant improvements across all three IL domains; Metaverse world usage, Metaverse world creation and HMD operation. Many began with little to no XR experience and participated passively at the outset. Through structured tutorials, hands-on activities, and collaborative design tasks, students developed both technical and communicative skills. These included navigating virtual environments, interacting with 3D objects, communicating effectively in VR, and ultimately building their own Metaverse worlds.

This learning trajectory is well explained by Kolb's experiential learning theory (1984), which emphasizes the cyclical nature of learning through four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. The design and presentation of Metaverse content allowed students to move through each phase as they transformed individual experience into shared understanding and applied insights into their world construction process.

In addition, many students acquired XR skills despite having no background in coding or 3D design. Their progress supports Bandura's self-efficacy theory (1977), which highlights the importance of mastery experiences in building confidence. The course structure—including peer collaboration, TA support, and low-pressure environments—appears to have enhanced students' confidence and motivation.

These two frameworks—experiential learning and self-efficacy—are widely recognized as foundational theories in educational psychology for explaining how learners acquire and apply complex skills (Schunk, 2012).

Importantly, this growth aligns with the concept of participatory digital literacy, which involves not just consuming, but actively creating digital content through meaningful interaction with tools and communities (Rheingold, 2012; Bawden, 2008). In this program, students did not remain passive receivers of XR media, but became co-constructors of immersive, culturally informed digital environments.

Together, these findings indicate that experiential, collaborative design activities within XR environments can foster information literacy even among novice users, especially when supported by structured instruction and community scaffolding.

5.2 Intercultural Competence and Virtual Exchange (Discussion for RQ2)

Statistically significant improvements were observed in students' IC, particularly in the domains of Intercultural Knowledge and Intercultural Sensitivity, thus addressing RQ2. Among the five subcomponents of Sensitivity, the most substantial gain was found in Interaction Confidence, notably in the item "I can communicate with people from different cultures very easily."

These improvements can be attributed to a sequence of immersive, collaborative learning experiences in the XR-based Metaverse environment. Notably, the largest pre-post increase among Intercultural Knowledge items was found in "I know some techniques to help me learn the target culture." This suggests that the course supported students in acquiring learning strategies essential for navigating unfamiliar cultural contexts.

This gain was facilitated by two key learning activities; 1) Cultural comparison and conceptualization: Participants selected a topic and engaged in critical comparison between their home and target cultures, guided by intercultural collaboration and 2) Collaborative world creation for peer learning: In mixed-nationality teams, students designed and built culturally themed Metaverse Worlds to provide classmates with new knowledge and stimulate deeper reflection and discussion. These activities were enhanced by authentic cultural materials, made accessible through real-time input from overseas participants. Such materials offered culturally grounded perspectives that strengthened content relevance and engagement.

Furthermore, learners explored the target culture through immersive embodied experiences using HMDs, interacting with grabbable content within the Metaverse. Through these dynamic encounters, they engaged in repeated cycles of intercultural interaction, real-time feedback, and reflection, which promoted deepened awareness and adaptability.

The marked improvement in Interactional Confidence is closely linked to the unique affordances of the XR environment. Unlike asynchronous exchanges, this setting provided synchronous, real-time interaction and responsive engagement, helping students gain communicative fluency and intercultural responsiveness. In contrast to traditional video conferencing, the Metaverse enables embodied communication through avatar gestures, spatial positioning, and shared virtual spaces.

This social presence fostered emotional connectedness and reduced psychological barriers, leading to greater confidence and increased willingness to engage. This outcome aligns with the notion of the affective filter (Krashen, 1982), in which emotional safety and motivation lower anxiety and facilitate language and cultural learning.

These gains are well explained by Kolb's (1984) experiential learning theory, in which learners progress through concrete experience, reflective observation, abstract conceptualization, and active experimentation. The iterative process of designing and presenting Metaverse Worlds aligns with this cycle, offering students authentic opportunities to internalize and apply intercultural knowledge and strategies.

Moreover, the observed improvement in confidence and engagement reflects the development of self-efficacy—a learner's belief in their own capabilities. While Bandura's (1977) theory emphasizes the role of mastery experiences, Schunk (2012) expands on this by situating self-efficacy within self-regulated learning, motivation, and performance in complex educational settings.

Finally, the observed improvements in affective and behavioral aspects—such as confidence, engagement, and attentiveness—underscore the value of immersive and synchronous Metaverse interactions. These findings align with Slater & Wilbur (1997) and Chen & Starosta (1997), who highlight social presence and mutual attentiveness as key to building trust and openness in intercultural communication.

5.3 Perceptions of Metaverse World Production Technology (Discussion for RQ3)

The post-activity survey results addressed RQ3 and revealed strong acceptance and satisfaction among Japanese participants with Metaverse World production technology. Most students rated the experience as enjoyable and valuable, citing increased motivation and perceived educational relevance (Table 5). These results suggest that students' engagement was deeply connected to the autonomy and creativity afforded by the learning task. Deci and Ryan's (1985) Self-Determination Theory explains that when learners feel competent, autonomous, and connected, their intrinsic motivation increases. The process of designing, collaborating in teams, and publicly presenting their own creations likely fulfilled these three basic psychological needs—autonomy, competence, and relatedness—thereby fostering intrinsic motivation.

High ratings for presence (Item 50) and intention to continue using the technology (Items 42–43) indicate strong engagement. This aligns with Slater and Wilbur's (1997) concept of presence as psychological immersion. The observed coherence between instructional design and perceived value also supports Biggs' (1996) theory of constructive alignment. Davis' (1989) Technology Acceptance Model (TAM) further explains that users are more likely to adopt technology when they perceive it to be useful and easy to use. Students' continued willingness to engage with Metaverse technology supports this model.

However, our findings also suggest that these two factors—usefulness and ease of use—are not sufficient on their own in educational XR contexts. Despite encountering some usability challenges, students overcame technical barriers with support and still expressed strong intention for future use. Rather, task designs that allow learners to exercise agency and creativity (e.g., student-led world creation) play a critical role in enhancing both satisfaction and long-term adoption intentions. This suggests the need to expand the TAM framework to include motivational dynamics such as intrinsic motivation.

Taken together, the results of RQ3 indicate that creating Metaverse Worlds in international learning contexts fostered emotional engagement, technological confidence, and self-directed learning. As shown in Table 5, students reported high levels of enjoyment (Item 46), meaningful learning experiences (Item 48), and motivation to use the technology again (Items 42–43). These findings underscore the importance of integrating learner autonomy and creative control into XR-based instructional design, especially in intercultural and collaborative learning environments where sustained engagement is crucial.

5.4 Limitations and Future Directions

This study demonstrates that student-led creation of Metaverse Worlds in XR environments effectively fosters both IL and IC, offering new perspectives on participatory learning by engaging students as content creators rather than passive users. Based on these findings, we recommend: (1) aligning clear learning objectives with structured technical support, (2) designing open-ended, collaborative tasks to promote student agency and creativity, and (3) incorporating reflective activities to deepen intercultural understanding. For XR platform developers, usability, real-time collaboration, and culturally diverse digital assets, such as virtual objects and environments, are important considerations. While teaching assistants supported both technical and intercultural learning, future work should explore AI-driven guidance and feedback to enhance scalability and learner autonomy.

However, this study is subject to several limitations. The small number of international participants limited cross-cultural comparisons and reliance on self-reported data may introduce bias. The one-semester duration was not sufficient to evaluate long-term outcomes and qualitative data collected were not analyzed here. Future research should include broader international cohorts, longer study durations, and comparisons of different XR platforms and activity types. In addition, exploring AI tutors, peer support systems, and learning analytics could deepen our understanding of learning processes. Analysis of the qualitative data collected will further clarify how XR-based, student-led environments contribute to IL and IC development in global education.

The findings of this study suggest potential applicability beyond the current higher education setting, particularly in the internationalization of primary and secondary education—as emphasized in the third pillar of the J-MIRAI initiative—and in line with OECD's strategic priorities for effective and inclusive digitalization and the role of higher education in upskilling and reskilling (OECD, n.d.). Although technical and institutional challenges remain for implementing XR and Metaverse-based approaches in these wider educational contexts, we believe that such barriers can be gradually addressed through the accumulated pedagogical expertise developed in this project and our ongoing efforts to integrate generative AI into educational support systems.

6. Conclusion

This study demonstrates that student-led, collaborative Metaverse world creation in synchronous VE enhances IL and IC among students. Quantitative results revealed significant gains in technical, communicative, and cultural competencies, confirming the effectiveness of this approach. In addition to measurable improvements, students reported high enjoyment, motivation, and positive perceptions of the immersive learning environment, emphasizing the intrinsic value of learner agency in XR-based education.

Beyond these findings, this research makes a novel contribution to the fields of educational technology and CSCL by showing how student-led creation in XR environments can concurrently foster the development of 21st-century skills. It advances ongoing scholarly discussions on how immersive, collaborative environments can integrate skill development with intercultural learning.

From a practical perspective, the successful implementation of MWCP underscores the importance of accessible and adaptable tools in making advanced XR content creation achievable for learners with varying technical backgrounds. As global education seeks scalable and engaging internationalization strategies—such as Japan's J-MIRAI initiative—our findings provide a strong, evidence-based model for incorporating immersive XR technologies into curricula. Furthermore, these implications resonate with OECD's policy priorities for inclusive digitalization and upskilling in higher education, reinforcing the relevance of this study in the broader context of international education policy.

Taken together, this study validates the educational value of student-created Metaverse environments and provides a robust foundation for advancing future research on learning in dynamic virtual spaces.

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