International Virtual Communities of Practice (I-VCoP) with Immersive Learning Ecosystem for Enhancing Critical Communication Skills in Multicultural Society

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***Abstract*—This research explores the integration of an Immersive Learning Ecosystem (ILE) within International Virtual Communities of Practice (I-VCoP) for enhancing critical communication skills in multicultural societies. The study aims to (1) conduct a PRISMA and bibliometric analysis of existing research related to Virtual Communities of Practice (VCoP), (2) develop I-VCoP with an immersive learning ecosystem, and (3) assess the critical communication skills of users engaged in I-VCoP activities. The immersive learning ecosystem leverages Virtual Reality (VR) and Augmented Reality (AR) technologies in order to create dynamic learning environments that foster engagement, retention, and the development of essential communication skills. Participants from diverse cultural backgrounds were assessed on critical communication skills, including cognitive flexibility, cultural awareness, language awareness, emotional and relational competence, ethical and social responsibility, metacognitive skills, and interpersonal and leadership skills. The results indicate a high level of appropriateness across all phases of the I-VCoP activities, with "Active Participation" receiving the highest evaluation score. The assessment of critical communication skills shows that participants achieved "Highest Proficiency" levels overall, with notable strengths in cognitive flexibility, cultural awareness, and interpersonal skills. The findings suggest that the integration of ILE within I-VCoP is highly effective in fostering critical communication skills necessary for success in multicultural environments. The study underscores the potential of immersive technologies to revolutionize virtual learning communities by providing engaging and culturally responsive learning experiences.**

***Keywords*—Virtual Communities of Practice (VCoP), immersive learning ecosystem, critical communication skills, multicultural society, metaverse, virtual reality, augmented reality**

I. Introduction

The Immersive Learning Ecosystem leverages Virtual Reality (VR) and Augmented Reality (AR) technologies in order to create realistic learning environments. These environments enable learners to interact with the content, thereby enhancing comprehension and retention. This ecosystem also promotes learner engagement by utilizing responsive and adaptive media, resulting in increased enthusiasm and participation. Additionally, the Immersive Learning Ecosystem offers diverse content tailored to individual learner needs, allowing them to choose topics of interest that align with their personal learning objectives. Moreover, the system can simulate complex scenarios, effectively developing learners' analytical thinking skill, critical thinking skill, problem-solving skill, and communication skills [1, 2].

Virtual Communities of Practice (VCoP) are groups of individuals who share a common interest or work in the same field. They connect with each other through online platforms in order to create and share knowledge, experiences, and best practices. The key principles of VCoP include member participation, knowledge creation and sharing, leveraging technology to support communication, continuous learning support, building trust and relationships, management and facilitation, and community evaluation and development [3].

The integration of the metaverse and immersive learning ecosystem with International Virtual Communities of Practice (I-VCoP) effectively enhances critical communication skills in multicultural societies. This is achieved through the creation of realistic communication environments, the practice of communication skills via immersive interactions, the simulation of cross-cultural communication scenarios, access to diverse learning resources and content, and the establishment of learning communities and peer support. Utilizing Metaverse technology in the development of communication skills within I-VCoP enables learners to adapt and cultivate essential skills for effective communication in multicultural societies [4, 5].

The objectives of this research are as follows:

1) To conduct the PRISMA and the bibliometrics analysis of research related to Virtual Communities of Practice (VCoP).
2) To develop International Virtual Communities of Practice (I-VCoP) with an immersive learning ecosystem for critical communication skills in a multicultural society.
3) To assess the critical communication skills of users of I-VCoP with an immersive learning ecosystem.

II. Theoretical Foundation

A. International Virtual Communities of Practice (I-VCoP)

I-VCoP play a crucial role in enhancing knowledge sharing

and professional development in healthcare settings across low- and middle-income countries [6]. Establishing and maintaining I-VCoP within healthcare organizations globally can optimize knowledge synthesis, skills development, and evidence-based practice implementation [7]. Research emphasizes the importance of utilizing standardized frameworks for guiding the design, implementation, and evaluation of I-VCoP to improve staff engagement, knowledge sharing, and ultimately enhance practice outcomes [7, 8]. The efficacy of I-VCoP, such as the Digital Learning Exchange (DigEx) in higher education, has been studied to support faculty and staff during transitions to online learning, highlighting the positive impacts and benefits of such virtual communities [9]. Additionally, the development of extended models like the life cycle knowledge flow model can further optimize knowledge sharing within I-VCoP, fostering a conducive environment for learning and professional growth.

I-VCoP are characterized by their ability to optimize knowledge management, foster social capital, stimulate innovation, and disseminate results [6]. These I-VCoP often consist of individuals from diverse disciplines engaging in informal continuing professional development sessions for the enhancement of their capacity and share expertise [10]. Establishing and facilitating I-VCoP organizations globally can lead to improved knowledge synthesis, evidence-based practice implementation, and staff engagement [11]. Furthermore, I-VCoP provide a platform for ongoing activities that support learning and professional development, creating transformative learning environments for professionals [7]. The development of I-VCoP using networked technology allows for the emergence of communities of practice with varying levels of expertise, fluid movement from novice to expert, and authentic tasks and communication, ultimately fostering collaborative learning and knowledge sharing [12]. The I-VCoP Characteristics are shown in Table 1:

Table 1. The characteristics of I-VCoP

I-VCoP Characteristics	Description	Reference
Knowledge Management	I-VCoP ability to optimize knowledge management, foster social capital, stimulate innovation, and disseminate results	[6, 10]
Collective Learning	I-VCoP involve members who interact regularly in order to share their experiences, expertise, and knowledge, fostering a culture of continuous learning and improvement.	[11, 13, 14]
Domain-Specific Focus	These communities are centered around a specific domain or field of interest, ensuring that members are engaged in relevant discussions and knowledge sharing.	[2, 4]
Online Platforms	I-VCoP utilize various online tools and platforms, such as immersive learning platforms, metaverse, forums, line, chatbot, wikis, and video conferencing, to facilitate communication and collaboration.	[9, 13–15]
Social Structures	The Multicultural Society and communities often develop social structures to support knowledge creation and sharing, such as roles, coordination mechanisms, and technology use.	[7, 13, 14]
Long-Term Management	I-VCoP require ongoing management and support to maintain their relevance and effectiveness over time.	[6, 13, 14]

I-VCoP provide enhanced global professional cooperation, more accessibility, and a global reach. Better organizational performance result from their facilitation of interprofessional knowledge sharing. The challenges encompass sustaining active member participation, surmounting cultural and technical obstacles, and guaranteeing continuous assessment and upkeep for their pertinence and efficacy. These advantages, nevertheless, are mostly reliant on continuing active involvement and getting beyond technological and cultural obstacles.

B. Immersive Learning Ecosystem (ILE)

An Immersive Learning Ecosystem (ILE) integrates physical and digital means like virtual reality and augmented reality to provide rich learning experiences [16]. In such environments, cognition is viewed as embodied, enacted, embedded, and extended, leading to entanglement with the virtual world and enhancing cognitive processes [17]. Modern immersive technologies enable learners to fully immerse themselves in authentic learning environments, collecting multimodal data for personalized feedback using artificial intelligence [18]. Virtual reality simulations, particularly in environmental education, offer spatial and temporal experiences that enhance understanding and motivation to solve environmental issues, encouraging active participation and knowledge retention [19]. Additionally, immersive learning systems based on virtual reality have been shown to improve learning outcomes, reduce errors, and increase interaction, demonstrating the effectiveness of VR in achieving educational goals [20].

With the utilization of cutting-edge technologies like VR, AR, MR, simulations, and games, ILE is an immersive learning ecosystem that produces dynamic and captivating learning environments. It tracks student progress, finds knowledge gaps, and offers individualized solutions using predictive analytics. With ILE, students may advance at their own speed and feel more relevant and in control of their education. The advice, criticism, and encouragement that human mentors and coaches offer helps close the knowledge gap between theory and practice. Advanced learning analytics tools are included in the ecosystem to analyze progress, keep an eye on student behavior, and pinpoint areas that need work. The purpose of ILE is to support a culture of continuous improvement and skill development by ensuring that learning experiences are pertinent to the organization's goals and objectives and are in line with the corporate strategy [21–25].

Although VR and AR have proven beneficial in creating immersive learning environments, critical perspectives highlight notable limitations in their application within educational contexts. Studies have observed issues such as high implementation costs, technical complexity, and the potential for cognitive overload among learners, which may

hinder optimal engagement and retention. Furthermore, VR/AR environments can sometimes lack accessibility for users with limited technological resources or specific physical requirements, potentially leading to inequalities in learning experiences. Integrating these considerations, this study acknowledges the challenges associated with VR/AR, emphasizing the need for adaptive, context-sensitive designs within I-VCoP that can effectively address these limitations while leveraging the transformative potential of immersive learning ecosystems.

The integration of metaverse environments in educational settings has shown promising potential for fostering interactive and personalized learning experiences. According to recent studies, metaverse technology can significantly enhance systematic and innovative thinking among learners, offering immersive engagement that traditional methods lack [26]. However, Hussain *et al*. [27] highlight key challenges that remain, including accessibility barriers, scalability concerns, and technical limitations in resource-constrained environments. These challenges are especially pertinent in hybrid or flexible learning models, where high costs and technical requirements may limit broader adoption(feduc-09-1411841). Addressing these constraints is critical for optimizing the use of metaverse-based educational frameworks, particularly within the context of International I-VCoP, where inclusivity and accessibility are essential for maximizing educational impact across diverse cultural settings.

An Immersive Learning Ecosystem (ILE) is a comprehensive framework that integrates various technologies and methodologies to create a holistic learning environment. The key components of an ILE are shown in Table 2:

Table 2. The key components of an Immersive Learning Ecosystem (ILE)

ILE components	Description	Reference
Immersive Learning Technologies	Virtual Reality (VR): Provides a fully immersive experience by simulating real-world scenarios. Augmented Reality (AR): Enhances real-world environments with virtual information and objects. Mixed Reality (MR): Combines elements of both VR and AR to create a seamless experience. Artificial Intelligence (AI) and Machine Learning: AI-powered tools that enhance learning through intelligent tutoring systems, automated grading, and natural language processing for personalized learning paths. Simulations: Replicates real-world scenarios to facilitate hands-on learning. Games and gamification: Engages learners through interactive and competitive experiences.	[17–19, 28, 29]
Immersive Learning Experience Platform (I-LXP)	Platforms that deliver, manage, and track educational content, enabling seamless integration of various learning materials and activities.	[19, 25, 29]
Collaborative Tools	Virtual Communities of Practice (VCoP): Online spaces where learners and instructors can interact in real-time, often featuring video conferencing, chat, and collaborative whiteboards. Social Learning Platforms: Forums, discussion boards, and social media integrations that facilitate peer-to-peer interaction and knowledge sharing.	[19, 21, 23]
Pedagogical Framework	Instructional design principles that guide the creation of immersive learning experiences, ensuring they are pedagogically sound and aligned with learning objectives.	[16, 21, 30]
Personalized Learning	Self-Paced Learning: Learners progress at their own speed, accommodating different learning styles and preferences. Adaptive Learning Technologies: Utilizes algorithms and data analytics to tailor learning experiences to individual learners' needs, providing personalized content and feedback. Repeatability: Learners can revisit complex concepts or scenarios multiple times until they fully grasp them.	[18, 19, 21]
Data Analytics	Predictive Analytics: Tracks learner progress, identifies knowledge gaps, and provides personalized interventions. Learning Analytics: Monitors learner behavior, tracks progress, and identifies areas for improvement.	[31–33]
Mentoring and Coaching	Assessment and Analytics: Tools that provide detailed insights into learner performance and engagement, enabling continuous improvement of the learning experience through data-driven decisions. Human Mentors and Coaches: Provide guidance, feedback, and support to learners, bridging the gap between theory and practice.	[19, 24, 34, 35]
Learning Analytics and Feedback	Real-Time Feedback: Learners receive immediate feedback on their performance, enabling them to adjust and improve. Data-Driven Insights: Analytics provide insights into learner behavior, helping to refine the learning experience.	[17, 19]
Just-in-Time Learning	Learners receive training and support exactly when they need it, enhancing the relevance and effectiveness of the learning experience. These components work together to create an immersive and engaging learning environment that fosters active participation, personalized learning, and effective skill development.	[19, 28, 36]

Immersive learning technologies, such as VR, AR, and MR enhance learning experiences by simulating real-world scenarios and combining elements of both. AI and machine learning tools enhance learning through intelligent tutoring systems, automated grading, and natural language processing. Simulations and games engage learners through interactive experiences. The I-LXP manages educational content and facilitates seamless integration. Collaborative tools like

VCoP and social learning platforms facilitate peer-to-peer interaction. Pedagogical frameworks guide the creation of immersive learning experiences. Personalized learning, adaptive learning technologies, and data analytics help tailor learning experiences to individual needs. Mentoring and coaching provide guidance, feedback, and support, while real-time feedback and just-in-time learning enhance the learning experience. By integrating these components, an immersive learning ecosystem provides a dynamic and interactive environment that enhances learning outcomes, fosters engagement, and supports continuous personal and professional development.

C. Critical Communication Skills in Multicultural Society

Critical communication skills are essential in multicultural societies, where individuals must navigate diverse cultural contexts. Studies emphasize the significance of Intercultural Communication Competence (ICC) for migrant workers, proposing a conceptual framework that includes antecedents like sensation seeking, ethnocentrism, and motivation to engage in intercultural communication, with cross-cultural adjustment as a consequence [37]. Furthermore, the development of foreign language communicative competence is crucial for graduates to succeed in global labor markets, emphasizing adaptability, interpersonal skills, and tolerance to foster effective professional communication with international partners [38]. Critical cultural awareness is highlighted as a key aspect of intercultural communication, aiming to develop learners who can engage with cultural plurality and enact positive change through language and attitude towards differences [39]. Additionally, virtual reality experiences have shown to enhance critical cultural awareness among students engaging in intercultural interactions, emphasizing the importance of practical experiences in improving intercultural competence [40]. The critical communication skills in a multicultural society are shown in Table 3.

Table 3. The critical communication skills in a multicultural society

Critical communication skills in a multicultural society	Description	Reference
Cognitive Flexibility and Cultural Awareness	Critical communicators in multicultural settings exhibit high cognitive flexibility, allowing them to understand and adapt to various cultural norms and communication styles. This involves being sensitive to sociocultural contexts and accepting diverse perspectives, which is crucial for effective interaction in a multicultural environment	[37, 38, 41]
Language Awareness	Proficiency in multiple languages and an understanding of language nuances play a significant role. These individuals are adept at using language to bridge cultural gaps, ensuring their communication is contextually appropriate and respectful of different cultural norms	[6, 42]
Emotional and Relational Competence	Effective communicators recognize the emotional dimensions of interactions. They are emotionally intelligent, demonstrating empathy and patience, and they adjust their communicative behavior to be culturally sensitive and inclusive	[38, 41]
Ethical and Social Responsibility	Ethical awareness and a sense of social responsibility underpin critical communication. Individuals are conscious of the impact of their words and strive to use language constructively, promoting mutual understanding and respect	[37, 41]
Metacognitive Skills	The ability to reflect on one's thought processes and communication strategies is vital. This self-awareness helps individuals adapt their communication to be more effective and appropriate in diverse cultural settings	[37, 40]
Interpersonal and Leadership Skills	Multicultural experience enhances leadership abilities. Leaders with broad multicultural experiences are better at adapting their communication styles to different cultural contexts, which leads to more effective team management and improved team performance	[6, 38]

The theoretical foundation of this study expands on prior research related to VCoP by incorporating immersive technologies, specifically VR and AR, into the I-VCoP framework. While earlier studies have explored the effectiveness of VCoP in facilitating knowledge sharing and collaboration, this research advances the existing body of knowledge by focusing on how immersive learning ecosystems can enhance critical communication skills in multicultural contexts. The study differentiates itself from traditional models by integrating immersive technologies to foster cognitive flexibility, cultural awareness, and leadership skills, enabling real-time practice of communication competencies in diverse, simulated environments. Through a detailed comparative analysis, this research highlights how these emerging technologies reshape learning dynamics within I-VCoP, addressing a critical gap in both the theory and practice of global professional communication.

III. Research Methodology

A. Research Scope

1) Population and sample

The population used in the research is people living in communities in six areas: America and Canada, Africa, Europe, Asia, the Middle East, and Oceania.

The sample group used in the research is people living in communities in six areas: America and Canada, Africa, Europe, Asia, the Middle East, and Oceania. Multistage randomization was performed by selecting people who wish to participate in the project voluntarily, 300 people, 50 people per area, and using simple random sampling to form a sample group of 180 people, 30 people per area.

2) Variables

The independent variable is the I-VcoP with an immersive learning ecosystem.

The dependent variable is critical communication skills in a multicultural society.

B. Methodology

1) Phase 1: The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) and the bibliometrics analysis of I-VCoP

This study was to systematically review the literature and the meta-analysis with PRISMA to find bibliometric

keywords related to I-VCoP with immersive learning ecosystem to enhance critical communications skills in multicultural society. The samples included book chapters, conference proceedings, and articles that were published in Scopus database. Since Scopus has a vast number of journal indexes and a style that allows for the definition of complicated search requirements, it was chosen as the database. Studies that are published in Scopus also often receive more citations than those that are published in other databases. Additionally, Scopus offers tools for bibliometric analysis, PRISMA meta-analysis, and systematic literature review data retrieval and export.

The study inclusion criteria included: (i) the articles that were published in open-access journals, presented at academic conferences, full edition, and published since 2010; (ii) the research papers whose title, abstract, and keywords matched the keywords of I-VCoP with immersive learning ecosystem, and (iii) the research papers that related to critical communication skills in multicultural society.

The keywords used included (TITLE-ABS-KEY ("Communities of Practice") AND PUBYEAR > 2009 AND PUBYEAR < 2025) AND (virtual OR online) AND (international) AND (immersive OR ar OR vr) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch")) AND (LIMIT-TO (LANGUAGE , "English")).

2) Phase 2: Development of I-VCoP with an immersive learning ecosystem for critical communication skills in a multicultural society

The development of the I-VCoP framework involved synthesizing key components of VCoP, immersive learning ecosystems, and the learning process, emphasizing the integration of critical communication skills. This phase combined immersive technologies such as VR and AR with established VCoP practices to enhance participants' cognitive and cultural competencies.

A learning model was created, visualizing the I-VCoP framework using diagrams that represented virtual worlds. These virtual environments were structured to simulate real-world, cross-cultural scenarios, allowing participants to practice communication skills in realistic, immersive settings.

The immersive learning platform was developed based on the I-VCoP process, offering a range of interactive experiences. These included role-playing activities, collaborative projects, and real-time feedback systems, all designed to mirror authentic multicultural environments. Participants engaged with the platform through VR and AR technologies, allowing them to experience and adapt to diverse communication challenges. While the immersive environment within the I-VCoP framework is designed to enhance cultural awareness, careful measures were implemented to prevent cultural bias and oversimplifications. The platform development process incorporated consultations with cultural experts from each represented region to ensure the accuracy and depth of cultural representations, avoiding stereotypes or misrepresentations. Scenarios and interactions within the virtual worlds were crafted to reflect authentic cultural diversity, encouraging participants to experience and navigate complex social and cultural nuances rather than simplified or stereotypical depictions. This approach aligns with the study's ethical commitment to fostering a respectful and realistic intercultural learning experience, reinforcing the I-VCoP's goal of cultivating a genuinely inclusive and culturally sensitive learning environment.

The appropriateness of the learning model and the immersive platform was evaluated by 15 experts using a standardized appropriateness assessment form. This form measured key aspects of the platform's design, implementation, and effectiveness, with data analyzed using the mean and standard deviation to ensure statistical reliability.

3) Phase 3: Assessment of critical communication skills in users of I-VCoP within an immersive learning ecosystem

180 participants from various regions—Americas and Canada, Africa, Europe, Asia, the Middle East, and Oceania engaged with the I-VCoP immersive learning ecosystem over an 8-week period. The structured virtual worlds were designed to immerse participants in culturally diverse scenarios, allowing for direct practice of communication skills in real-time interactions. During the study, attrition was monitored, resulting in a dropout rate of approximately 0.5 %. To address participant attrition, a replacement sampling protocol was implemented to maintain consistency across the sample. This approach ensures that the findings remain robust and representative of diverse cultural backgrounds, facilitating a comprehensive assessment of critical communication skills within the immersive learning ecosystem of I-VCoP.

The critical communication skills assessment tool evaluated six key competencies: (1) cognitive flexibility and cultural awareness, (2) language awareness, (3) emotional and relational competence, (4) ethical and social responsibility, (5) metacognitive skills, and (6) interpersonal and leadership skills. These competencies were measured using a 5-point scale with a detailed scoring rubric. Each competency's results were derived from participant interactions within the immersive virtual worlds, ensuring a comprehensive evaluation of communication skills in diverse cultural contexts. The total possible score was 30 points, reflecting the depth and complexity of each competency.

IV. Research Result

A. The Systematic Reviews and Meta-Analyses (PRISMA) and the Bibliometrics Analysis of I-VCoP

After querying results with Communities of Practice keywords published in Scopus, the 14,422 research papers were analyzed using a bibliometric analysis. The results are shown in Fig. 1. Therefore, the 14,422 research papers from the Scopus database were used to systematically review the literature and meta-analysis. According to the research selection criteria,

- excluding "virtual" or "online" research, there were 6,320 research papers remained,
- excluding non-international virtual communities of practice research, there were 5,112 research papers

remained,

- excluding non-immersive or AR or VR research, there were 229 research papers remained,
- excluding non-open access research studies, there were 90 research papers remained.
- excluding research document type published since 2010, there were 88 research papers remained,
- excluding research document type that was not published in research journals and academic conferences, and book chapter there were 81 research papers remained,
- excluding non-English language there were 74 research papers remained.

The studies included in review for meta-analysis were 74 research papers. The results of the PRISMA analysis for I-VCoP are shown in Fig. 2.

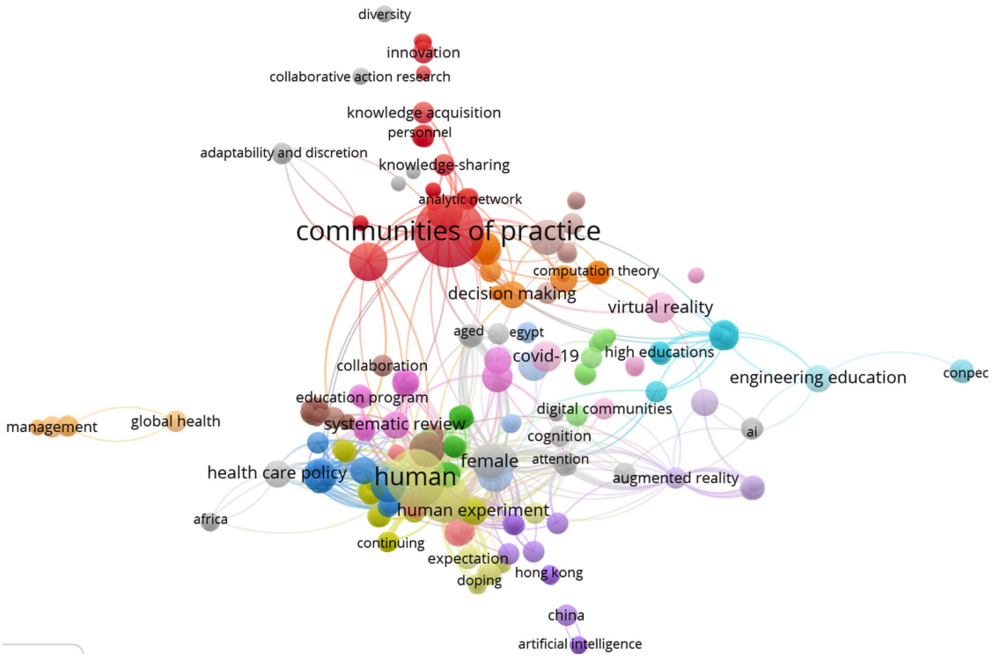

Fig. 1. Bibliographic from I-VCoP queries in Scopus database.

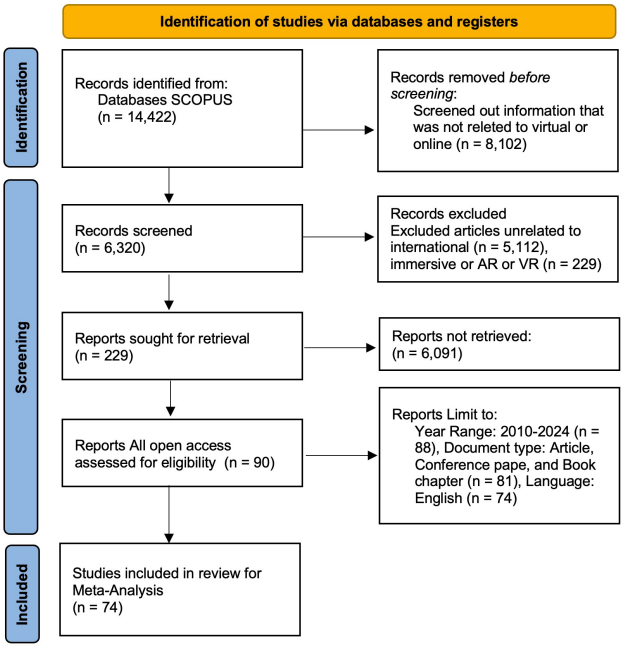

Fig. 2. The systematic reviews and Meta-Analyses (PRISMA) of I-VCoP.

As shown in Fig. 3, The keywords of I-VCoP with immersive learning ecosystem consisted of career readiness, computer aided instruction, metaverse for higher education, metaverse platform architecture, learning cycle, learning experiences, 21st century skill, metaverse instructional design, experiential learning, high educations, engineering education, network architecture, community of practice, collective intelligences, immersive learning, ecosystem, metaverses learning systems, and virtual reality.

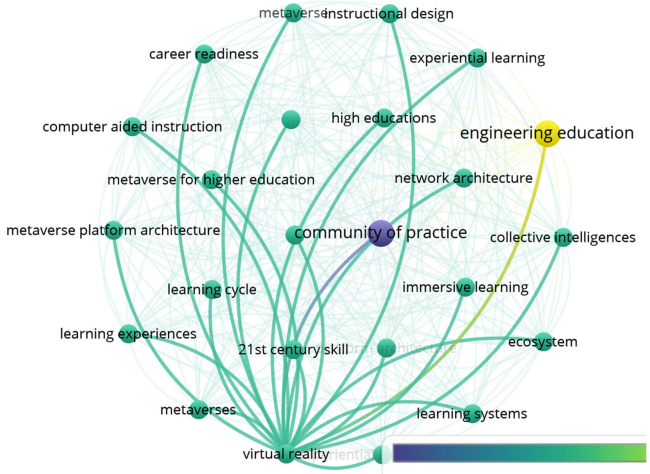

Fig. 3. The bibliometrics analysis of I-VCoP.

B. The I-VCoP with an Immersive Learning Ecosystem for Critical Communications Skills in a Multicultural Society

1) The process of I-VCoP

The process of I-VCoP consists of 6 steps as follows:

a) Conceptualization: CoPs start with the identification of a common domain of interest or practice. This initial phase involves a small, core group of practitioners who share a passion for a particular topic and see the potential for mutual benefit through collaboration. The group's shared vision, purpose, and roles are defined

during this stage

b) Formation: In this phase, the community begins to organize and establish its structure. Key activities include defining the strategies for interaction, communication, and engagement. Initial meetings and activities are planned to build momentum and attract more members

c) Growth and Development: As the community matures, it attracts a wider range of participants with varying levels of involvement. Members might engage in activities such as workshops, webinars, hackathons, and other collaborative events. The community continuously evolves through regular retrospectives and feedback sessions to ensure it meets the members' needs

d) Active Participation: CoPs thrive on active engagement from their members. This phase is characterized by high levels of collaboration, knowledge sharing, and problem-solving. Members contribute to a growing body of shared knowledge and best practices, fostering a culture of continuous learning and improvement

e) Sustainability and Scaling: To ensure long-term sustainability, CoPs must focus on maintaining their relevance and value. This involves fostering trust, encouraging open communication, and providing resources such as meeting spaces and funding. Leaders play a crucial role in supporting the community's activities and recognizing the contributions of its members

f) Evaluation and Closure: a CoP may reach its objectives or experience a decline in participation. At this stage, it is essential to evaluate the community's impact, celebrate successes, and consider retiring the CoP if it no longer serves its purpose. This closure can lead to the formation of new CoPs, ensuring the continuous flow of knowledge and innovation within the organization

The I-VCoP process and activity using immersive learning ecosystem are shown in Table 4.

Table 4. The I-VCoP process and activity using immersive learning ecosystem

I-Virtual Communities of Practice Process	Immersive Learning Ecosystem	Activities
Step 1: Conceptualization **Goal:** Define the common domain of interest, shared vision, purpose, and roles. **Outcome:** A well-defined vision, purpose, and roles for the community.	• **Meeting Space:** Host an initial meeting with the core group of practitioners. Use virtual conference rooms to discuss and define the community's vision and purpose. Utilize presentation tools to share ideas and gather feedback. • **Collaboration Space:** Use virtual whiteboards and sticky notes for brainstorming sessions. Breakout rooms can facilitate small group discussions to explore different aspects of the community's focus and potential activities.	• **Kick-off meeting**: Set the stage with an agenda that includes vision setting and role definition. • **Vision workshop**: Participants collaboratively create a vision board using virtual whiteboards. • **Role clarification**: Break into smaller groups in breakout rooms to discuss and define specific roles and responsibilities.
Step 2: Formation **Goal:** Organize the community structure, plan initial activities, and build momentum. **Outcome:** An organized community structure with an initial engagement plan.	• **Meeting Space:** Conduct planning sessions to establish communication strategies, interaction methods, and engagement plans. Use calendar integrations to schedule regular meetings. • **Activities Space:** Plan and host introductory events such as virtual mixers, orientation sessions, and team-building activities to attract new members.	• **Planning meetings**: Define community rules, interaction strategies, and communication platforms. • **Introductory events**: Host virtual events like meet-and-greet sessions, interactive presentations, and informal social gatherings to welcome new members and build rapport. • **Initial content** creation: Develop initial resources and documentation in the Knowledge Sharing Space to provide new members with a foundational understanding of the community's goals and activities.
Step 3: Growth and Development **Goal:** Expand the community, enhance member engagement, and evolve through regular feedback. **Outcome:** A growing and evolving community that meets the needs of its members.	• **Activities Space:** Host a variety of interactive events such as workshops, webinars, and hackathons to attract diverse participants and encourage active involvement. • **Meeting Space:** Conduct regular retrospectives and feedback sessions to assess community progress and identify areas for improvement. • **Knowledge Sharing Space:** Continuously update and expand the library of resources, best practices, and learning materials based on member contributions and feedback.	• **Interactive events**: Schedule regular workshops, webinars, and collaborative hackathons to engage members. • **Retrospectives**: Hold feedback sessions in the Meeting Space to discuss what's working well and what can be improved. • **Resource updates**: Encourage members to contribute new materials, tutorials, and case studies to the Knowledge Sharing Space.
Step 4: Active Participation **Goal:** Foster high levels of collaboration, knowledge sharing, and problem-solving. **Outcome:** High levels of engagement, collaboration, and knowledge sharing among members.	• **Collaboration Space:** Facilitate regular collaboration sessions where members can work together on projects, share ideas, and solve problems. • **Meeting Space:** Organize regular knowledge-sharing meetings, where members present their experiences, challenges, and solutions. • **Knowledge Sharing Space:** Maintain forums and discussion boards for continuous Q&A, knowledge exchange, and sharing of best practices.	• **Collaboration sessions**: Regularly scheduled meetings for project work, brainstorming, and peer reviews. • Knowledge-sharing meetings: Members present case studies, success stories, and lessons learned. • **Online forums**: Use discussion boards to facilitate asynchronous communication and problem-solving.
Step 5: Sustainability and Scaling **Goal:** Ensure the long-term sustainability and relevance of the community. **Outcome:** A sustainable and thriving community that remains relevant and valuable to its members.	• **Meeting Space:** Hold regular leadership meetings to discuss community strategy, funding, and resource allocation. Ensure open communication and transparency. • **Support Hub:** Provide continuous support and resources for members, including technical assistance and mentoring programs. • **Social Space:** Recognize and celebrate member contributions and achievements through social events and informal gatherings.	• **Leadership meetings**: Discuss long-term strategy, funding opportunities, and resource needs. • **Support initiatives**: Establish mentoring programs, technical support channels, and member onboarding processes. • **Recognition events**: Host social events to celebrate achievements, award recognitions, and build community spirit.
Step 6: Evaluation and	• **Meeting Space:** Conduct formal evaluation sessions and	• **Evaluation Sessions:** Use the Meeting Space to conduct

I-Virtual Communities of Practice Process	Immersive Learning Ecosystem	Activities
Closure **Goal:** Evaluate the community's impact, celebrate successes, and determine if the CoP should be retired or evolved into a new form. **Outcome:** A thorough evaluation of the CoP's impact, a celebration of its successes, and a clear decision on whether to retire or evolve the CoP. This ensures a smooth transition and fosters continuous knowledge sharing and innovation within the organization	discussions regarding the future of the CoP. • **Activities Space:** Host celebratory events to acknowledge the contributions and successes of the community. • **Knowledge Sharing Space:** Document the outcomes, lessons learned, and valuable resources created by the CoP. • **Social Space:** Facilitate informal gatherings to celebrate the community's journey and provide closure.	formal evaluations of the CoP's achievements, impact, and areas for improvement. Invite all members to share their feedback and insights. • **Success Celebrations:** Organize events in the Activities Space to celebrate the accomplishments of the community. This could include awards ceremonies, showcases of successful projects, and recognition of key contributors. • **Documentation:** In the Knowledge Sharing Space, compile a comprehensive report detailing the CoP's journey, key outcomes, lessons learned, and valuable resources. Ensure this documentation is accessible for future reference and new CoPs. • **Closure Discussions:** Hold meetings in the Meeting Space to discuss the potential retirement of the CoP. Evaluate whether the CoP has fulfilled its purpose and if it should evolve into a new CoP. • **Informal Gatherings:** Facilitate informal gatherings in the Social Space to allow members to reflect on their experiences, say goodbyes, and discuss future opportunities for collaboration.

2) The system architecture of an Immersive Learning Experience Management Platform (I-LXMP)

The system architecture of an I-LXMP integrates various technologies and components to create an interactive, engaging, and effective learning environment. The I-LXMP comprising multiple layers that support the operation of a Learning Experience Management Platform (LXMP) and the creation of learning experiences within the context of a Virtual Community of Practice (V-CoP). The system architecture of an I-LXMP explanation of each layer is as follows:

(1) User Interface Layer (Virtual Immersive Technology)

- VR/AR/MR Devices: Headsets, goggles, and other wearable devices that provide immersive experiences.
- Desktop and Mobile Applications: Applications that allow users to access the system from computers and mobile devices, interfaces for accessing the platform from are computers, tablets, and smartphones.
- Haptic Devices: Devices that enable users to interact with and feel virtual objects through tactile feedback, tools that provide tactile feedback to enhance immersion.

(2) Content Management System (CMS)

- Content Creation Tools: Tools used to create and edit learning content, applications for developing VR/AR content, simulations, and interactive learning materials.
- Content Repository: A storage system for managing and organizing learning content that can be easily accessed and distributed.
- Content Delivery Network (CDN): A network system that facilitates the rapid and efficient delivery of digital content to end users. Ensures efficient distribution of content to users across different geographical locations.

(3) Learning Experience Management Platform (LXMP)

- User Management: Tools for managing user information, such as registration, grouping, and progress tracking, handles user registration, authentication, and profile management.
- Course Management: Tools for creating, organizing, designing and managing courses and learning modules, including scheduling and monitoring progress.
- Assessment and Evaluation Tools: Tools used to assess learning outcomes and measure learner success. Systems for creating and administering quizzes, tests, and other assessment methods.

(4) Collaboration and Communication Tools

- Virtual Community of Practice (V-CoP): An online platform that supports knowledge exchange and collaboration within communities of shared interest or profession. The V-CoP environments where participants and experts can interact in real-time.
- Immersive Meeting Spaces: Online meeting spaces that simulate virtual reality experiences, such as VR, AR technologies for group discussions and collaborative projects.
- Social Networking Features: Tools for peer interaction, discussion forums, and community building. Features that enable users to build networks and communicate via social media platforms.

(5) Analytics and Reporting

- Learning Analytics: Tracks and analyzes learner interactions and progress to provide insights into learning effectiveness. The use of data to analyze and evaluate user learning performance.
- Reporting Tools: Tools used to generate reports that summarize data and present analytical results. Generate reports on learner performance, course completion rates, and other metrics.

(6) Integration Layer

- APIs (Application Programming Interfaces): A set of protocols that facilitate efficient communication and data exchange between different software systems. For integrating with other educational technologies and third-party services. Interoperability Standards: Ensures compatibility and seamless interaction between different systems and platforms.

(7) Security and Privacy

- Data Encryption: Encryption processes are employed to protect sensitive data from unauthorized access, and protects sensitive information from unauthorized access.
- User Privacy Controls: Tools that allow users to manage personal data and set access permissions, and allows users to manage their personal data and privacy settings.

- Compliance: Adherence to standards and regulations related to data security and privacy and adheres to regulations such as GDPR, FERPA, and other data protection laws.

(8) Backend Infrastructure

- Cloud Services: Cloud services provide scalable storage and processing capabilities, such as AWS and Google Cloud. Provides scalable storage, computing power, and network resources.
- Database Management: The database management system plays a critical role in efficiently organizing and storing all data, and manages user data, content metadata, and other critical information.
- Server Infrastructure: The configuration and maintenance of servers ensure stable and responsive service delivery, and supports the hosting and delivery of the platform's services and applications.

The system architecture of an I-LXP shown in Fig. 4 and the international virtual communities of practice process using immersive learning ecosystem shown in Fig. 5, and the international virtual communities of practice activity shown in Figs. 6 and 7.

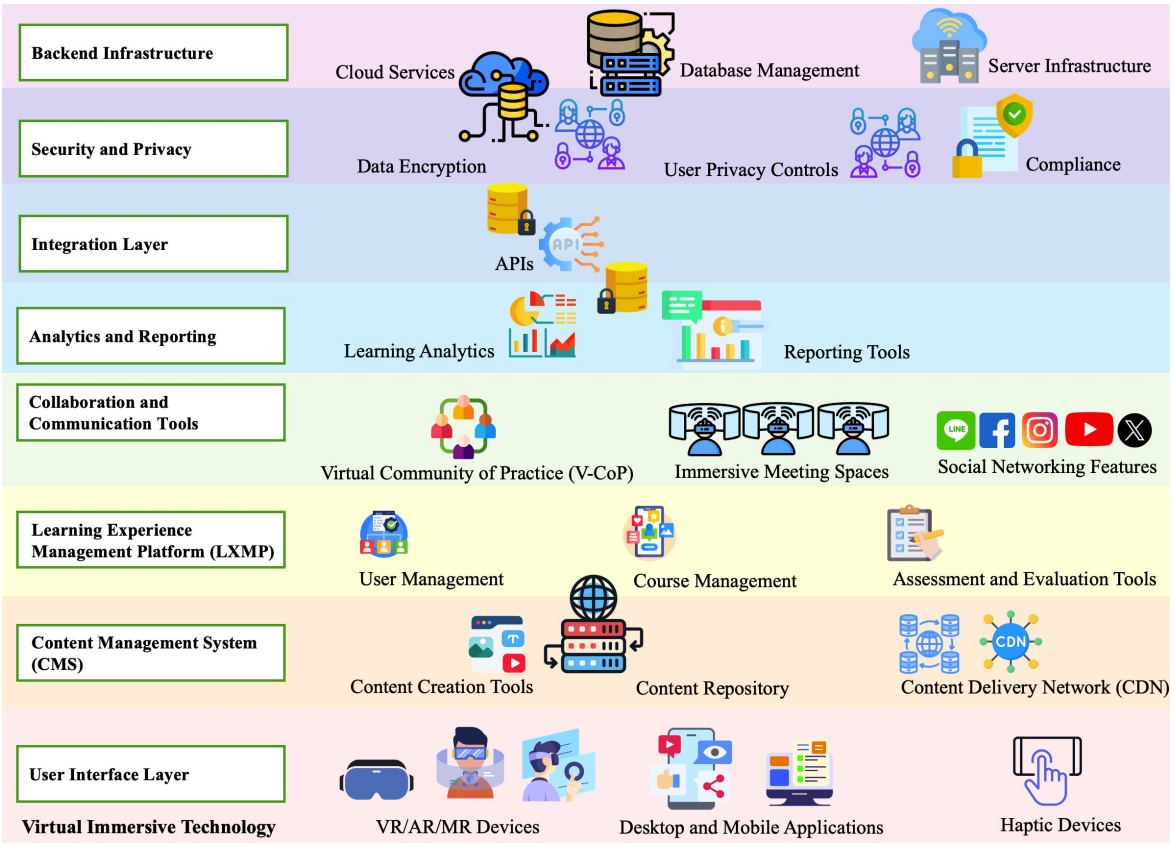

Fig. 4. The system architecture of an I-LXMP.

Fig. 5. The I-VCoP activity using immersive learning ecosystem.

Fig. 6. The I-VCoP activity on metaverse virtual environment.

Fig. 7. The I-VCoP activity in physical environment.

C. Results of the Evaluation of Appropriateness of an Immersive Learning Experience Management Platform (I-LXMP)

From Table 5 the overall evaluation of the I-LXMP platform reveals a high level of appropriateness across all components, with a rating of "Highly Appropriate" (Mean = 4.75, S.D. = 0.49). This score indicates the platform's suitability for supporting Communities of Practice (CoP) and collaborative activities, demonstrating strong potential in enhancing learning and engagement within a virtual community. The high evaluation scores reflect the platform's capacity for effective implementation, particularly in key areas.

Table 5. The results of the evaluation of appropriateness of the I-LXMP (n = 15)

I-LXMP	*Mean*	*S.D.*	Appropriate level
User Interface Layer (Virtual Immersive Technology)	4.67	0.62	Highly Appropriate
Content Management System (CMS)	4.87	0.35	Highly Appropriate
Learning Experience Management Platform (LXMP)	4.87	0.35	Highly Appropriate
Collaboration and Communication Tools	4.80	0.41	Highly Appropriate
Analytics and Reporting	4.73	0.46	Highly Appropriate
Integration Layer	4.80	0.41	Highly Appropriate
Security and Privacy	4.60	0.74	Highly Appropriate
Backend Infrastructure	4.67	0.49	Highly Appropriate
Overall	4.75	0.49	Highly Appropriate

Notably, the LXMP received the highest evaluation scores, indicating their exceptional suitability for creating and managing learning experiences within a virtual community of practice, the CMS component received the highest evaluation scores, highlighting its robust capabilities for content creation and management, with support for VR/AR-compatible tools and repositories that facilitate efficient organization of educational content. The Collaboration and Communication Tools, along with the Integration Layer, also scored highly, signifying user satisfaction with real-time collaboration capabilities, forums, and immersive meeting spaces, which collectively enhance interactivity within the I-VCoP. Furthermore, the Analytics and Reporting Tools closely follow, underscoring the system's robustness and effectiveness in supporting data-driven insights and continuous improvement within educational environments.

D. Results of the Evaluation of Appropriateness of the I-VCoP Activity Using Immersive Learning Ecosystem

From Table 6 The evaluation results for the appropriateness of the I-VCoP activities using an immersive learning ecosystem indicate a high level of suitability across all steps. Each phase of the I-VCoP activity has been rated as "Highly Appropriate," showcasing the effectiveness of the immersive learning ecosystem in facilitating these activities (Mean = 4.71, S.D. = 0.46), reinforcing the appropriateness of the system in supporting the conceptualization, formation, growth, participation, sustainability, and evaluation of virtual communities of practice. These rankings highlight that Step 4: Active Participation received the highest evaluation score, indicating its exceptional effectiveness in the I-VCoP activities. Steps 1, 3, and 6 followed closely, emphasizing their strong suitability in the process. Step 5: Sustainability and Scaling also demonstrated a high level of appropriateness, making it an integral part of the overall immersive learning ecosystem. In summary, Table 6 illustrates rsive learning ecosystem significantly supports the I-VCoP process, fostering collaboration, growth, and sustainability. The consistently high ratings across all phases validate the platform's effectiveness in creating a dynamic and supportive virtual learning environment that aligns with the goals of a multicultural community of practice.

Table 6. The results of the evaluation of appropriateness of the I-VCoP activity using immersive learning ecosystem (n = 15)

I-VCoP activity	*Mean*	*S.D.*	Appropriate level
Step 1: Conceptualization	4.73	0.46	Highly Appropriate
Step 2: Formation	4.60	0.51	Highly Appropriate
Step 3: Growth and Development	4.73	0.46	Highly Appropriate
Step 4: Active Participation	4.80	0.41	Highly Appropriate
Step 5: Sustainability and Scaling	4.67	0.49	Highly Appropriate
Step 6: Evaluation and Closure	4.73	0.46	Highly Appropriate
Overall	4.71	0.46	Highly Appropriate

E. Results of the Assessment of Critical Communication Skills in Users of I-VCoP within an Immersive Learning Ecosystem

From Table 7 The assessment of critical communication skills among users of I-VCoP within an Immersive Learning Ecosystem indicates that participants generally exhibit a very high level of proficiency in these essential skills. The overall mean score is 4.72, S.D. is 0.52, placing the participants in the "Highest Proficiency". This suggests that users are highly capable of effectively communicating, adapting, and collaborating within the virtual community.

Table 7. The results of the assessment of critical communication skills in users of I-VCoP (n = 180)

Critical communication skills	Mean	S.D.	Skill level
Cognitive Flexibility and Cultural Awareness (5)	4.88	0.32	Highest Proficiency
Language Awareness (5)	4.78	0.42	Highest Proficiency
Emotional and Relational Competence (5)	4.67	0.47	Highest Proficiency
Ethical and Social Responsibility (5)	4.69	0.62	Highest Proficiency
Metacognitive Skills (5)	4.48	0.70	High Proficiency
Interpersonal and Leadership Skills (5)	4.80	0.40	Highest Proficiency
Total Score (30)	4.72	0.52	Highest Proficiency

The highest-rated skill is cognitive flexibility and cultural awareness, which indicates that users are particularly adept at adapting their thinking and understanding cultural nuances within the I-VCoP. Interpersonal and leadership skills and language awareness also ranked highly, demonstrating strong abilities in communication and leadership. Overall, the participants' critical communication skills are at the "Highest Proficiency" level, with only metacognitive skills slightly lower, but still within the "High Proficiency" range. This suggests that users are well-prepared to engage and succeed in the immersive learning environment of the I-VCoP.

V. Discussion

The findings of this research underscore the effectiveness of integrating International Virtual Communities of Practice (I-VCoP) with an Immersive Learning Ecosystem in enhancing critical communication skills within a multicultural society. The high appropriateness ratings across all phases of the I-VCoP activities, as reflected in the evaluation results (Mean = 4.71, S.D. = 0.46), indicate the robustness of the immersive learning ecosystem in facilitating the conceptualization, formation, growth, and sustainability of virtual communities. Particularly noteworthy is the exceptional effectiveness of Step 4: Active Participation, which received the highest evaluation score. This suggests that active engagement in the immersive learning environment significantly contributes to the development of critical communication skills among participants.

The assessment of critical communication skills further validates the efficacy of the I-VCoP framework. The overall mean score of 4.72 (S.D. = 0.52) across various communication competencies positions the participants at the "Highest Proficiency" level. This indicates that the immersive learning ecosystem not only supports but enhances the users' ability to navigate complex, multicultural communication scenarios effectively. The highest-rated skill, cognitive flexibility and cultural awareness, highlights the capacity of the I-VCoP to foster adaptability and cultural sensitivity—key attributes for effective communication in diverse settings. Moreover, the strong performance in interpersonal and leadership skills underscores the role of I-VCoP in cultivating leadership qualities necessary for managing and communicating within global teams. Interestingly, while metacognitive skills scored slightly lower, they still fall within the "High Proficiency" range. This suggests that while users are adept at reflecting on and regulating their communication strategies, there is potential for further development in this area. The inclusion of more targeted interventions within the I-VCoP framework could help elevate these skills to the same high level as the other competencies assessed. The findings align with existing literature on the importance of immersive technologies and virtual communities in enhancing communication skills. The use of VR, AR, and other immersive technologies within the I-VCoP framework appears to be a key driver in creating realistic and engaging learning environments that promote the development of critical communication skills. This supports previous studies that have highlighted the potential of immersive learning environments to enhance cognitive and social competencies in multicultural contexts [6, 15, 30, 43].

VI. Conclusion

This study demonstrates the effectiveness of International Virtual Communities of Practice (I-VCoP) combined with an Immersive Learning Ecosystem in enhancing critical communication skills in multicultural societies. The high appropriateness ratings across all I-VCoP phases and the "Highest Proficiency" levels in communication skills among participants underscore the framework's value. By leveraging immersive technologies, the I-VCoP creates an engaging environment where learners develop essential competencies such as cognitive flexibility, cultural awareness, and leadership skills. While the results are largely positive, the slightly lower proficiency in metacognitive skills indicates an area for potential improvement. Future enhancements could focus on integrating more reflective practices and emerging technologies to further strengthen these skills. This research contributes to the growing evidence that immersive learning ecosystems and virtual communities are effective tools for preparing individuals for the complexities of global communication. The I-VCoP framework presents a promising approach for educators and practitioners aiming to equip learners with the communication skills necessary for success in the 21st century.

This study highlights the significant potential of integrating immersive learning ecosystems within I-VCoP to foster critical communication skills in multicultural settings. While opportunities exist to expand VR accessibility in economically diverse regions, these considerations also open pathways for future research. Addressing these aspects by broadening VR accessibility and incorporating objective assessment tools will enhance the inclusivity and accuracy of I-VCoP implementations. By doing so, future iterations of this model can achieve even broader impacts, making immersive cultural learning experiences more accessible and reliable for diverse communities worldwide.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

W.S. contributed to the research design, data collection, and analysis. They played a significant role in the conceptualization and development of the study's framework and were involved in drafting and revising the manuscript. S.K. was responsible for the literature review, developing the research methodology, and coordinating the data collection process. They also contributed to interpreting the results and provided critical revisions to the manuscript. N.W., as the corresponding author, led the overall research project, supervised the research process, and ensured the integrity and accuracy of the work. They were heavily involved in writing, editing, and finalizing the manuscript, ensuring it adhered to academic standards. C.A., and P.W. provided expertise in the immersive learning ecosystem, contributing to the theoretical framework and analysis. They also assisted in data interpretation and provided substantial feedback during the manuscript's preparation. S.L. contributed to the analysis of

the critical communication skills assessment, supported the data interpretation, and was involved in the review and refinement of the manuscript. All authors contributed to completing the paper and had approved its final version.

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