Enhancing 3C Skills Through Generative AI and Metaverse in Higher Education: An Innovation Project

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Abstract
This study investigates an innovative educational project aimed at enhancing university students' critical thinking, collaboration, and communication (3C) skills through the integration of Generative Artificial Intelligence (AI) and Metaverse. Conducted at a Japanese university, the project planned and implemented by five professors from three different faculties of the university brought together students from the three faculties to collaboratively address social issues using cutting-edge digital tools. The research adopted a mixed-methods approach with pre- and post-project surveys and focus group interviews to investigate whether they perceived they had improved the 3C skills. The results of the analysis of the surveys and interviews showed that the students perceived an improvement in their 3C skills. They perceived that they had demonstrated enhanced capabilities in presenting structured arguments, engaging in complex discussions, and delivering impactful presentations. This research underscores the potential of these emerging technologies to prepare students for the demands of the modern workforce by fostering essential skills in problem-solving, teamwork, and digital communication. The findings contribute to the growing body of knowledge on technology-enhanced education, offering valuable implications for educators and policymakers. Future iterations aim to refine instructional approaches, expand international collaboration, and explore the long-term impacts of technology integration on higher education outcomes.

Keywords: Critical Thinking, Collaboration, and Communication (3C) Skills, Generative AI, Metaverse

Introduction

The rapid evolution of digital technologies has profoundly transformed how individuals learn, communicate, and collaborate. In the realm of education, these advancements present unique opportunities to address long-standing challenges in skill development, particularly in fostering communication, collaboration, and critical thinking (3C) skills. These competencies are increasingly vital in a globalized and interconnected workforce that demands effective interdisciplinary problem-solving and adaptable communication strategies. Despite their importance, traditional educational methods often fall short of adequately preparing students in these areas.

Conventional classroom settings are frequently constrained by rigid structures that prioritize theoretical knowledge over practical application. Students are seldom exposed to real-world challenges requiring dynamic problem-solving, and opportunities for cross-disciplinary collaboration are often limited. These limitations create a gap between academic learning and the practical demands of modern professional environments. Generative Artificial Intelligence (AI) and Metaverse are two cutting-edge technologies with the potential to redefine educational practices. Generative AI, represented by tools like ChatGPT, enables interactive and personalized learning experiences, offering resources for creative problem-solving and adaptive content delivery. The Metaverse, a network of immersive virtual environments, facilitates collaboration and interaction beyond the constraints of physical space, fostering engagement and experiential learning. Together, these technologies provide powerful tools to enhance education, particularly in developing 3C skills.

This study explores the integration of Generative AI and Metaverse into higher education through a structured framework designed to cultivate students' 3C skills. Focusing on university students engaged in an interdisciplinary project addressing real-world social issues, the study examines how the project helped the students improve 3C skills. This paper details the design and implementation of this innovative project, analyzes its impact on students' 3C skill development, and discusses its implications for future educational practices.

Generative AI, defined as a deep learning technology capable of creating human-like content in response to various prompts (Lim et al., 2023), represents a transformative advancement in educational technology. ChatGPT-4, developed by OpenAI, exemplifies this innovation through its capacity to process and generate content across multiple modalities, including text, audio, image, and video (OpenAI, 2024). This capability has paved the way for unprecedented opportunities in personalized learning and skill development. Tools such as ChatGPT can function as virtual tutors, study aids, and assessment tools, providing students with immediate feedback and tailored support (UNESCO, 2023). Recent research highlights the pivotal role of Generative AI in fostering collaborative and task-based learning environments. Sako (2024) demonstrated that AI-assisted collaborative language learning enhances critical thinking by encouraging students to analyze, synthesize, and present ideas effectively. Similarly, Ruiz-Rojas et al. (2024) found that Generative AI tools enhance team-based problem-solving and foster deeper engagement in higher education contexts. These tools facilitate collaborative learning by adapting to diverse educational needs and promoting student-driven inquiry. Generative AI has also shown promise in integrating into project design and collaborative processes.

Metaverse, defined as the convergence of virtual reality (VR) and augmented reality (AR) technologies enabling multimodal interactions with virtual environments, digital objects, and

people (Mystakidis, 2022), has emerged as a transformative platform in education. Meta (2022) envisions Metaverse as a space that allows individuals to "socialize, learn, collaborate, and play in ways that go beyond what we can imagine." Its immersive environments offer students interactive and experiential learning opportunities that promote collaboration and creativity. Metwally et al. (2024) emphasized Metaverse's potential to facilitate project-based learning, where students work collaboratively to solve complex challenges. By providing a shared virtual space, Metaverse enables seamless interaction, fostering teamwork and critical thinking. Onu, Pradhan, and Mbohwa (2024) highlighted Metaverse as an advanced educational platform, emphasizing immersive environments that enhance engagement and collaboration. Metwally et al. (2024) further explored how Metaverse enables collaborative, project-based learning while promoting creativity and critical thinking through team-based initiatives.

Although the potential of integrating Generative AI and Metaverse has been discussed in recent studies, no research has specifically examined an interdisciplinary group project in which university students from different departments collaboratively explore how these technologies can be used to solve real-world issues and present their ideas. Additionally, no study has investigated the impacts of such projects on students' communication, collaboration, and critical thinking (3C) skills. Therefore, this study examines whether an interdisciplinary group project, where students consider how Generative AI and Metaverse can be utilized to address societal challenges, can enhance their 3C skills.

Methods

This study adopted a mixed-methods approach to investigate the integration of Generative AI and Metaverse technologies into higher education and their impact on students' communication, collaboration, and critical thinking (3C) skills. The methods section outlines the project design, participant recruitment, and data collection and analysis procedures. Quantitative data from questionnaires measured skill development, while qualitative insights from focus group interviews explored students' experiences and challenges. This approach ensured a comprehensive evaluation of the project's effectiveness in fostering interdisciplinary collaboration and enhancing 3C skills.

Project Background and Design

In today's rapidly evolving digital society, it is essential for university students to acquire a deep understanding of cutting-edge technologies such as Generative AI and Metaverse, not only to enhance their academic development but also to prepare them for future societal roles. Additionally, cultivating students' competencies in communication, collaboration, and critical thinking (3C) skills is essential for their success in a globalized world. To help students acquire knowledge about the latest technologies, such as Generative AI and Metaverse, and to develop 3C skills, five professors from three different departments at a private university in Japan have initiated a project. In this project, students from the three departments work collaboratively in groups to discuss how Generative AI and Metaverse can be used to solve global problems. This interdisciplinary approach also addresses the challenge of limited opportunities for interdisciplinary collaboration and skill-building among students at our university, which has campuses spread across different locations. Furthermore, the project incorporates global perspectives by engaging students in collaborative projects with international peers, thereby enhancing their English communication skills and preparing them for leadership roles in a globalized world.

The project is conducted in two phases. Phase 1, from March to July 2024, involved Japanese university students from the three departments. These students worked in interdisciplinary teams to design solutions to social issues using Generative AI and Metaverse technologies. This phase culminated in a competitive ideathon where teams presented their ideas and received expert feedback. The ongoing Phase 2 extends the project to include international collaboration with a U.S. university. Cross-cultural teams have been formed to address global challenges, designing solutions to social issues using Generative AI and Metaverse technologies. This phase also features an ideathon where teams present their solutions and engage in peer-to-peer learning. This paper will focus on Phase 1.

Participants of the Study

To recruit students from the three departments, a brochure about the project was created and shared through a Learning Management System as well as distributed by the five faculty members. Initially, 34 students from the three departments applied for the project. Since the expected number of participants was approximately 35, all applicants were selected. The 34 students were divided into six groups. However, one group did not function well because all its members were too busy. Consequently, the remaining five groups, comprising 27 students, continued to work on the project and participated in the ideathon.

Data Collection and Analysis

A mixed-methods approach was used to evaluate the project of Phase 1. To investigate whether the project contributed to improving the participants' communication and collaborative skills, a questionnaire survey was conducted. A focused group interview was also conducted to explore whether the project helped them improve communication, collaborative and critical thinking skills. In this section, first, the data collection of the questionnaire and its analysis is explained. Following that, the data collection of the interview and its analysis is provided.

Data Collection and Analysis of the Questionnaire. The questionnaire on Communication and Collaboration skills was developed with reference to the Common European Framework of Reference for Languages (CEFR) Companion Volume (Council of Europe, 2020). The Can-Do descriptors used as a reference covered B1 to C2 levels, focusing on sustained monologue, informal discussion, formal discussion, goal-oriented online transactions and collaboration, online conversation and discussion, and addressing audiences.

For sustained monologue, the B1 and B2 levels were referenced. For example, at the B2 level, learners "can develop an argument systematically with appropriate highlighting of significant points, and relevant supporting detail." In terms of informal discussion, the B2 and C1 levels were included. At the B2 level, participants "can take an active part in informal discussion in familiar contexts, commenting, putting a point of view clearly, evaluating alternative proposals and making and responding to hypotheses." For formal discussion (meetings), the B2 level was referenced. For example, individuals at this level "can keep up with an animated discussion, identifying accurately arguments supporting and opposing points of view." Regarding goal-oriented online transactions and collaboration, the B1 to C1 levels were included. At the B2 level, they "can collaborate online with a group that is working on a project, justifying proposals, seeking clarification and playing a supportive role in order to accomplish shared tasks." For online conversation and discussion, the B2 and C1 levels were referenced. At the B2 level, learners "can engage in online exchanges between several

participants, effectively linking their contributions to previous ones in the thread, provided a moderator helps manage the discussion." Finally, for addressing audiences, the B2 to C2 levels were referenced. At the B2 level, speakers "can give a clear, systematically developed presentation, with highlighting of significant points, and relevant supporting detail."

A five-point Likert scale with 5=strongly agree, 4=agree, 3=neither agree nor disagree, 2=disagree, and 1=strongly disagree was used for both a pre- and post-questionnaire. For the questionnaires, 25 students answered the pre-questionnaire, and 24 students answered the post-questionnaire.

Data Collection and Analysis of the Interviews. To investigate whether the project helped promote participants' communication, collaboration, and critical thinking skills, a focused group interview was conducted with the five groups. The interviews followed a semi-structured format, including both prepared and additional questions related to these three skill domains.

For example, in the communication domain, participants were asked, "How were you able to communicate effectively with students from other faculties?" and "What specific measures did you take to ensure smoother interactions during online meetings?" In the collaboration domain, questions included, "How did your team divide roles and cooperate throughout the project?" and "What specific strategies or approaches were particularly helpful when brainstorming ideas as a team?" Additionally, to examine online collaboration, participants were asked, "What efforts or measures did you take to ensure that all team members actively participated in the online environment?" For the critical thinking domain, participants were prompted with questions such as, "Through the preparation and progress of the ideathon, what changes occurred in your way of thinking?" and "How did you deepen your own thoughts or experience situations where you accepted others' opinions?"

The semi-structured format was chosen for its balance between structure and openness, allowing for consistent data collection across groups while also providing flexibility to explore unexpected yet relevant themes that emerged during the interviews (Gillham, 2005). This approach provided a comprehensive understanding of how the project influenced the development of communication, collaboration, and critical thinking skills.

Following the interviews, the data were analyzed with a specific focus on critical thinking skills. While questions related to communication and collaboration provided valuable context for understanding the broader team dynamics, the analysis of this study focuses on identifying themes and patterns that demonstrated growth in participants' critical thinking abilities.

Thematic analysis was employed to categorize and interpret the data, with particular attention given to participants' reflections on how their thought processes evolved throughout the project. The analysis utilized a combination of content analysis and thematic analysis to systematically examine both the manifest content of the reflections and uncover recurring themes. As Kvale and Brinkmann (2009) explain, "Content analysis is a technique for a systematic quantitative description of the manifest content of communication" (p. 203). Key aspects examined included the ability to evaluate diverse perspectives, the integration of feedback, and evidence of higher-order thinking such as analysis, synthesis, and evaluation. By combining the structured nature of content analysis with the depth of thematic analysis,

the study was able to capture both the explicit elements of participants' responses and the underlying themes that signified growth in critical thinking skills.

Results

In this section, the findings from the study are presented in two parts. First, the results of the questionnaire are analysed to evaluate the measurable improvements in participants' self-assessed communication and collaboration skills. Then, the insights derived from focus group interviews provide a qualitative understanding of the development of critical thinking abilities.

Results of the Questionnaire

The results of the questionnaire analysis demonstrate statistically significant improvements in communication and collaboration skills following the intervention. This section presents an overall comparison of pre- and post-questionnaire scores, detailed item-specific findings, and an analysis of effect size.

The mean score for the pre-questionnaire was 2.97, which increased to 3.27 in the post-questionnaire, reflecting a mean difference of 0.30. The effect size, as measured by Cohen's d, was 0.67, indicating a medium effect size. This suggests that the observed improvements are both statistically significant and practically meaningful. A paired t-test analysis revealed a p-value of 0.023, indicating that the improvement in participants' self-assessed skills is unlikely to have occurred due to random variation.

A closer examination of individual questionnaire items highlights significant improvements across multiple areas. Table 1 summarizes the items with statistically significant differences between the pre- and post-questionnaire scores, along with their corresponding p-values. For instance, Item 1 ("I can present organized arguments by clearly identifying the main points") shows a mean difference of 0.42 (p=0.012), while Item 26 ("I can give well-prepared and clear presentations, explain specific viewpoints, and discuss the pros and cons of various options") shows a mean difference of 0.41 (p=0.005).

Table 1: Statistically Significant Items in the Questionnaire

Items	Pre-Mean	Post-Mean	Mean Difference	P-Value
1. I can present organized arguments by clearly identifying the main points.	2.96	3.38	0.42	0.012
3. I can briefly explain the reasons for my opinions.	2.88	3.25	0.37	0.037
4. I can participate in and contribute to complex discussions with other participants in group discussions, even on abstract and difficult topics.	2.80	3.29	0.49	0.018
7. I can accurately express my ideas and opinions and persuasively explain and respond to complex arguments.	2.76	3.25	0.49	0.023
10. I can effectively participate in online discussions about complex and abstract issues by asking for or providing further details as needed.	2.84	3.29	0.45	0.015

14. I can participate in online collaboration and provide clear instructions to achieve objectives.	2.88	3.29	0.41	0.047
19. I can use visual materials to communicate with project partners or small groups online and explain complex concepts in an easy-to-understand way.	2.84	3.25	0.41	0.017
21. I can confidently and clearly explain complex topics to listeners who may lack prior knowledge	2.72	3.12	0.40	0.033
22. I can give clear and well-structured presentations on complex topics, using supporting points, reasons, and relevant examples.	2.92	3.23	0.41	0.020
26. I can give well-prepared and clear presentations, explain specific viewpoints, and discuss the pros and cons of various options	2.92	3.33	0.41	0.005

In summary, the intervention enhanced participants' self-assessed communication and collaboration abilities. Improvements were observed across a range of areas, including the ability to present arguments, participate effectively in discussions, collaborate online, and deliver structured presentations. These results underscore the positive impact of the intervention in achieving its objectives.

Results of the Focused Group Interviews

To evaluate the development of critical thinking skills among participants, focused group interviews were conducted following a semi-structured format. This method combined pre-prepared questions with spontaneous follow-ups and the interviews were analyzed using a combination of thematic and content analysis. The analysis revealed three main themes related to critical thinking development: incorporating new perspectives, preparation through research and understanding challenges, and improving critical thinking habits. Each theme is detailed below, supported by participants' direct quotes.

Incorporating New Perspectives. One of the key outcomes was the participants' ability to broaden their perspectives through interactions with peers and external experts. The questions designed for the interviews specifically prompted reflections on how participants integrated diverse opinions into their thought processes, which revealed notable growth in their critical thinking.

> During the presentation, there were individuals in other teams who had experienced school absenteeism, and one of the Microsoft persons also shared her personal experience of school absenteeism. This kind of feedback, based on real-life experiences, provided insights that I could not have discovered on my own or through online research. It allowed me to incorporate new perspectives. (Group B)

> There were moments when my way of thinking changed through discussions with other group members. For instance, we investigated supporting information and incorporated new perspectives to enhance the feasibility of our claims and ideas. (Group C)

These insights demonstrate how participants gained new perspectives through collaboration, which enriched their understanding of complex issues and informed their decision-making.

Preparation Through Research and Understanding Challenges. Another major theme was the role of research and problem-solving in fostering critical thinking skills. Interview questions targeting the preparation phase of the ideathon uncovered participants' reflections on how they identified and addressed challenges through in-depth analysis and evidence gathering.

> With the theme of the metaverse and AI, I had never worked on such business or idea generation projects before. As a result, I feel that my critical thinking skills in this field significantly improved. (Group B)

> I learned to understand and focus on the limitations of Generative AI, such as its opacity and black-box nature, recognizing these as significant issues to address. (Group C)

> When presenting our ideas, we decided to include legal and technical issues during Phase 1. We managed to incorporate supporting facts and evidence to address these challenges. (Group D)

These examples illustrate how participants engaged in research to deepen their understanding of critical issues, evaluate potential solutions, and refine their approaches, all of which contributed to the development of critical thinking.

Improving Critical Thinking Habits. The interviews also highlighted participants' ability to cultivate habits that supported critical thinking. Questions focusing on shifts in participants' thought processes revealed progress in their ability to critically evaluate their ideas, balance competing considerations, and adopt more analytical approaches to decision-making.

> By listening to various opinions, I became able to critically evaluate my own ideas, such as recognizing risks or flaws in my thinking. (Group A)

> Rather than focusing solely on the positive aspects, I developed the ability to consider problems critically, allowing for more balanced and rational decision-making. (Group C)

> I developed the habit of staying calm and not focusing solely on the positive aspects, which allowed me to think more critically. (Group D)

These reflections underscore how participants improved their capacity for higher-order thinking by challenging their assumptions, integrating feedback, and adopting a more reflective approach to decision-making.

Summary of the Interview. The use of semi-structured interviews allowed for a comprehensive exploration of participants' experiences, capturing both structured responses and unexpected insights into their critical thinking development. The combination of thematic and content analysis revealed three distinct dimensions of growth: incorporating diverse perspectives, leveraging research to address challenges, and cultivating critical thinking habits. These findings demonstrate how the ideathon project provided a conducive environment for fostering critical thinking, equipping participants with skills relevant to collaborative and real-world problem-solving.

Discussion and Conclusion

This study investigated how integrating Generative AI and Metaverse technologies into an interdisciplinary educational project contributed to the development of students' communication, collaboration, and critical thinking (3C) skills. The results demonstrated measurable improvements in participants' communication and collaboration abilities, as evidenced by statistically significant increases in their self-assessed skills following the intervention. Participants reported enhanced abilities to articulate arguments, present ideas clearly, and engage in online collaboration effectively.

Focus group interviews revealed significant development in participants' critical thinking skills, a central objective of the project. Participants described how engaging with diverse perspectives deepened their understanding of complex issues and informed their decision-making. These reflections support the findings of Sako (2024) and Ruiz-Rojas et al. (2024), who emphasized the importance of collaborative environments in fostering critical engagement. Participants also demonstrated their ability to analyze and address challenges, such as incorporating technical and legal considerations into their project ideas. Furthermore, participants noted improvements in reflective habits, such as questioning assumptions, critically evaluating ideas, and balancing competing viewpoints. These habits, essential for cultivating higher-order thinking, were evident in participants' ability to identify and address weaknesses in their reasoning. The project also facilitated interdisciplinary collaboration, allowing participants to effectively divide roles, manage online teamwork, and incorporate feedback from team members and external experts. Through this project, participants engaged in conceptualizing how Generative AI and Metaverse could be applied to address societal challenges. This reflective process encouraged creativity and critical analysis, demonstrating the value of envisioning technological applications.

This study has several limitations. First, the findings are based on self-reported data from participants, which may introduce biases such as overestimation of their skills. Additionally, while the study explored the potential of Generative AI and Metaverse, the analysis did not include an in-depth exploration of how participants' knowledge of these technologies evolved during the project, even though related data were collected in the interviews. Addressing these gaps in future analyses could provide a more comprehensive understanding of the learning process.

Future research will address these gaps and expand on the findings. The next phase of this project (Phase 2) includes the participation of university students from the United States, fostering a more diverse and international collaboration. The ideathon will also be conducted in English, enabling us to examine improvements in English communication and international collaboration skills. These new dimensions provide an opportunity to explore how language and cross-cultural interactions influence the development of 3C skills. Longitudinal research is also needed to investigate the sustained impact of such interventions on students' professional competencies and their adaptability to dynamic technological and collaborative environments.

This study highlights the transformative potential of combining Generative AI and interdisciplinary collaboration to enhance essential 21st-century skills. By encouraging students to conceptualize how these technologies could address real-world challenges, educators can create learning experiences that bridge theoretical knowledge and practical application. This approach fosters interdisciplinary collaboration, critical thinking, and

reflective learning, preparing students for the complexities of a globalized, technology-driven workforce.

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