The effect of metaverse technology on multicultural learning: Strengthening the social attitudes, cultural awareness and critical thinking skills of secondary school students

Prisana Mutchima[1]
Yutthapong Leelakitpaisarn[2]
Bunpod Pijitkamnerd[3]
Nattha Phiwma[4]
Saisuda Pantrakool[5]

(✉ Corresponding Author)

[1,2,3,4,5]*Suan Dusit University, Bangkok, Thailand.*
[1]*Email: Prisana_mut@dusit.ac.th*
[2]*Email: Yutthapong_lee@dusit.ac.th*
[3]*Email: Bunpod_pij@dusit.ac.th*
[4]*Email: Nattha_phi@dusit.ac.th*
[5]*Email: Saisuda_pan@dusit.ac.th*

Abstract

The purpose of this study is to investigate the effect of metaverse technology on multicultural learning to strengthen the social attitudes, cultural awareness and critical thinking skills of secondary school students. Methodology: A quasi-experimental research method was used in this study to equally divide 80 secondary school students in the Dusit district, under the Office of the Basic Education Commission, Bangkok, Thailand into an experimental group and a control group. The experiment of the metaverse on multicultural learning in an eight week teaching period comprised four components: virtual cultural exploration, role-playing, discussions and reflections, and collaborative projects. The results showed a significant difference in the average outcomes between the groups. In conclusion, the major findings include three dimensions: 1) Students who learn through metaverse technology have a higher learning progress than students in traditional classrooms. 2) Social attitudes and critical thinking skills from utilizing metaverse technology in learning are both statistically significant. 3) The overall assessment proves that metaverse technology improves students' learning outcomes. Therefore, this study supports the integration of metaverse technology into education, especially in developing thinking skills and social competence in multicultural learning. The metaverse supported teachers' instruction to enhance students' social, cultural, and critical thinking skills.

Keywords: Critical thinking skills, Cultural awareness, Metaverse technology, Multicultural learning, Social attitudes, Virtual learning environments.

Contents

Contribution of this paper to the literature
This study is original in its focus on the comparative impact of metaverse technology versus traditional methods specifically in fostering social attitudes, critical thinking, and cultural awareness. It uniquely integrates these dimensions to evaluate metaverse efficacy, highlighting its potential for developing higher-order skills and social competencies in multicultural education.

1. Introduction

Digital technology plays an important role in learning and teaching management to contribute creativity, communication, and collaboration in the current era of education (Chua & Yu, 2024). The metaverse is one of the era technologies providing a new form of communication that connects the virtual world with user experience. Moreover, the metaverse also has the ability to create avatars in the metaverse world, the place where virtual identities of people can meet, chat, work and study together in any space including freely doing all manner of activities (Shurygin, Anisimova, Orazbekova, & Pronkin, 2023).

The application of the metaverse with a constructivist approach to teaching influences learners to become familiar with virtual technology (Rahman, Shitol, Islam, Iftekhar, & Saha, 2023). Learning through metaverse technology can strengthen learners to have a better understanding of the social context with diverse cultures while also meeting students' needs as a medium through virtual worlds and learning media. Digital natives are passionate about new technologies. Therefore, teachers must use updated digital learning and teaching materials like 3D technologies such as metaverse technology (Marini et al., 2022). The metaverse is used as a demonstration material for digital media and helps learners to acquire knowledge and information (Singh, Malhotra, & Sharma, 2022). Experience from the metaverse also encourages students to think critically when facing real-life problems and situations and have excellent problem-solving skills.

One of the essential learner skills is critical thinking (Kavenuke, Kinyota, & Kayombo, 2020). Critical thinking skills play a major role in promoting a learner's psychological, moral, social and cognitive development (Mohd Darby & Mat Rashid, 2017). The key to critical thinking skills development is letting learners play a role in the learning process (Boso, van der Merwe, & Gross, 2021). Furthermore, cultivating learners' critical thinking skills significantly affects their problem-solving abilities and their social attitudes which reflect their behavior (Tapung, Maryani, & Supriatna, 2018). Attitude is defined as the ability to think and accept, beliefs, interests, viewpoints and trends (Surahman & Mukminan, 2017). Social attitude is another factor that learners should develop. Learners have positive or negative expressions about social conditions. This is the foundation for human communication and coexistence in society. However, social attitudes refer to the relationships and interdependence between individuals. They can be attributed to sustained interpersonal interactions starting from communication, information exchange, and social coexistence (family, community, school and society) (Groenewoudt, Rooks, & van Gool, 2019). For students, social attitude is important because it is the foundation for effective communication with teachers and friends. It contributes to acceptance and cooperation within society. Therefore, promoting positive social attitudes among students is especially important in a multicultural society like Thailand.

Thailand is a multicultural society with various ethnicities, races and religions. In spite of the diversity, most people are able to coexist peacefully (Waters & Michael, 2022). However, problems and conflicts have been faced in some regions especially in the southern border provinces where people have strong cultural and religious differences. The root causes of these conflicts are multifaceted and inclusive of historical, political, economic, and social factors. Economic inequality issues had led to social conflicts. These challenges indicate that without effective management, social attitudes and analytical thinking skills among the population remain weak. This phenomenon may lead people to have a lack of social harmony and mutual trust. Finally, the conflicts have the power to impact entire communities and societies. Addressing these issues requires a deep understanding of multiculturalism and the interaction with the local community. Therefore, the understanding of social differences in education is necessary, especially for secondary school students where cultivating a sense of coexistence and social attitudes are indispensable.

Multicultural learning activities through metaverse technology create equal educational opportunities for all students, especially for students from different races and social classes. All students have equal accessibility to necessary knowledge, attitudes, and social perspectives through the metaverse world. In practice, multicultural education is a social integration strategy to encourage people to coexist in society effectively. The management of multicultural learning activities requires a comprehensive design of teaching (Rahman et al., 2023).

Utilizing metaverse technology for multicultural learning to enhance students' social attitudes, cultural awareness and critical thinking skills requires the most comprehensive instructional design and management for their direct learning experience (Rahman et al., 2023). Metaverse technology is an effective tool for creating an enjoyable learning experience for children (Chen, Zou, Xie, & Wang, 2023). In addition, new technologies have the capability to create more attractive learning of social science, languages and cultural disciplines. For example, it may encourage students from the local community of Dusit district, Bangkok, the capital of Thailand to learn about multiculturalism (Chinese, Khmer, Westerners, and Thai) through real places and simulations. Therefore, the metaverse can be used to support teachers in instructional adaptation as well as play an important part in enhancing social attitudes, cultural awareness and the critical thinking skills of all students.

The purpose of this study was to investigate the effect of metaverse technology on multicultural learning, social attitudes, awareness, and critical thinking skills of junior school students. This study used social learning theory to learn various behaviors. Positive social attitudes towards multiculturalism can be modeled and enhanced by observing others and assuming virtual interactions within the metaverse. The theory of creative learning further supports this theory. Introducing engaging experiences helps students to establish deeper levels of knowledge. In addition, cultural intelligence theory is an introduction to multicultural backgrounds. It can enhance people's adaptability and empathy in culturally diverse societies. Meanwhile, critical thinking theory is an analysis and questioning of social interactions that promote high-level thinking. Therefore, this study used these frameworks to answer two main questions: (1) How does metaverse technology affect the development of secondary school students' social attitudes and cultural awareness? (2) How can this technology effectively promote analytical thinking through multicultural learning? Finally, this study aims to determine whether the metaverse can be used as a valuable tool to build the necessary multicultural competencies in today's interconnected world.

2. Literature Review

2.1. Metaverse Technology in Multicultural Education

The metaverse is a virtual reality platform that seamlessly integrates Augmented Reality (AR) and Virtual Reality (VR) providing users a real-time interactive digital space. The metaverse provides immersive learning experiences and significantly increases student engagement and comprehension in the educational landscape (Mystakidis & Christopoulos, 2022).

The term "metaverse" combines "meta," meaning beyond with "universe," which means to describe a parallel or virtual environment that connects to the physical world. Neal Stephenson first introduced the concept of the metaverse in the 1992 science fiction novel named 'Snow Crash'. In this story, as time goes by people explore the digital world through their own incarnations to escape the challenges of the real world. The development of the metaverse covers many different interpretations, including shared virtual spaces, a mirrored world, and a specific or spatial internet. New forms of internet applications and social structures are integrating emerging technologies. The post-reality universes are persistent multi-user environments that merge physical and digital worlds. These all-encompassing universes serve as spaces for simulation, collaboration and life-logging (Mystakidis & Christopoulos, 2022).

The metaverse is presented in various ways such as virtual classrooms, simulations, and virtual tourism in multicultural education systems. The metaverse encourages students to participate in authentic learning experiences that they may not be able to achieve in the real world. At the same time, the use of the metaverse in the education system faces many challenges, including the challenge of unequal access to technology as well as issues with privacy and cybersecurity. Multicultural research aims to promote an understanding and acceptance of multiculturalism, race, religion and society. The ultimate goal is to promote social equality and justice. Multicultural education is crucial for students to grow in a diverse society in today's digital age.

Multicultural learning can be applied to various forms of teaching activities in a multi-person society. For example, it can be used to insert cultural content into the curriculum with the indoctrination of multicultural teaching activities. Moreover, it can create a classroom environment that encourages the acceptance of differences. The metaverse can also encourage multicultural learning such as creating simulated experiences, where learners learn through virtual worlds and carry out collaborative activities. It also enables learners to have positive views, understand and accept the increase of cultural differences (Ahn et al., 2021).

The term "social attitudes" describes the inclinations people have towards social issues or circumstances in their thoughts, feelings, and behaviors which affect the choices and actions they make daily (Eagly & Chaiken, 1993). Young people's positive social attitudes are essential to create a society based on empathy, understanding and shared responsibility.

Teachers can help students build social attitudes through a variety of techniques such as case studies, group discussions, and service-learning projects (Metzger et al., 2018). Furthermore, the metaverse presents chances to develop simulated environments in which students can safely hone their social expression and decision-making skills which may influence their social attitudes and awareness in the actual world. Critical thinking requires a methodical, introspective process that involves carefully assessing data or circumstances before making decisions or drawing conclusions. Analysis, interpretation, evaluation, inference, explanation and self-regulation are essential elements of critical thinking and are becoming essential in the 21st century's information-rich world. A variety of techniques, like asking open-ended questions, examining case studies, and involving secondary school students in multicultural learning projects that call for analytical thinking to develop critical thinking abilities. The metaverse can further improve these abilities by providing intricate, difficult simulated scenarios that push students to think critically and make thoughtful judgments.

Effective problem-solving is made possible by the multifarious process of critical thinking, which allows for the methodical assessment of intricate concepts. Using problem-solving, questioning, reasoning, and perspective-taking to arrive at clear, succinct, accurate, logical, and proper solutions is the ultimate goal of critical thinking abilities.

2.2. Social Attitudes, Consciousness Development, and Critical Thinking Skills in Secondary School Students

Social attitude refers to people's tendency towards various social issues or situations, in terms of their thoughts, emotions, and behaviors which affects their daily choices and actions (Eagly & Chaiken, 1993). In addition, a positive social attitude among young people is crucial for social development. People's coexistence in society is based on empathy. They share a common understanding and sense of responsibility. These positive attitudes can be encouraged through various techniques. For example, case studies, group discussions, and learning service projects can be conducted. Teachers can encourage students to establish social attitudes (Metzger et al., 2018). In addition, the metaverse provides opportunities to develop simulation environments where students can practice social expression skills and make correct and safe decisions to solve problems. This may affect their social attitudes and real-world awareness.

Analytical thinking requires a systematic process and self-exploration which involves careful evaluation of information or situations. Analysis, interpretation, evaluation, inference, explanation, and self-regulation are important components of critical thinking. Critical thinking is increasingly important in a world full of information. In the 21st century, techniques such as asking open-ended questions, investigating case studies, and engaging middle school students in learning projects are common as is learning about multiculturalism in societies of different ethnicities. Social coexistence requires critical thinking. For example, creating simulated events, simulating problems, simulating complex and intricate scenarios. Moreover, applying meta technologies can enhance analytical thinking skills and is also an effective solution. Students have various analytical thinking processes and they can systematically evaluate complex concepts. The goal of critical thinking is to solve problems, identify issues, find answers, reason, and view problems from different perspectives in a concise, accurate, reasonable and suitable way for various situations in daily life.

3. Methods

3.1. Research Design

This study employed a quasi-experimental research design and was conducted by the following two groups: an experimental group learning by using a metaverse platform designed for multicultural learning, and a control group with traditional teaching methods. Both groups were given pre- and post-tests to compare the differences of the effect.

3.2. Participants

The participants consisted of secondary school students from The Office of The Basic Education Commission in Bangkok, Thailand. The sample size was determined using a purposive sampling technique from a school located in the Dusit district (Ratchawinit School) of Bangkok and from outside the district (Wat Suthivararam School). The samples were selected from the diversity of races, religions and characteristics. A total of 80 students participated and were divided into 2 groups of 40 students for the experimental and 40 students for the control groups.

Table 1 presents the research design.

Table 1. Research design.

Groups	Research design		
Experimental group	O1	X	O2
Control group	O3	Z	O4

Note: O1: Pre-test of the experimental group, O2: Post-test of the experimental group.
O3: Pre-test of the control group, O4: Post-test of the control group.

3.3. Research Instruments

3.3.1. Experimental Instrument: Metaverse-Based Lessons for Multicultural Learning

The development process includes: 1) Studying relevant theories and research on multicultural learning and metaverse technology. 2) Designing the lesson structure and content, considering the learning objectives. 3) Developing metaverse-based lessons in collaboration with experts in technology and education (see Figure 1). 4) Conducting a pilot study with a group of students similar to the target sample. 5) Revising the lessons based on the pilot study results.
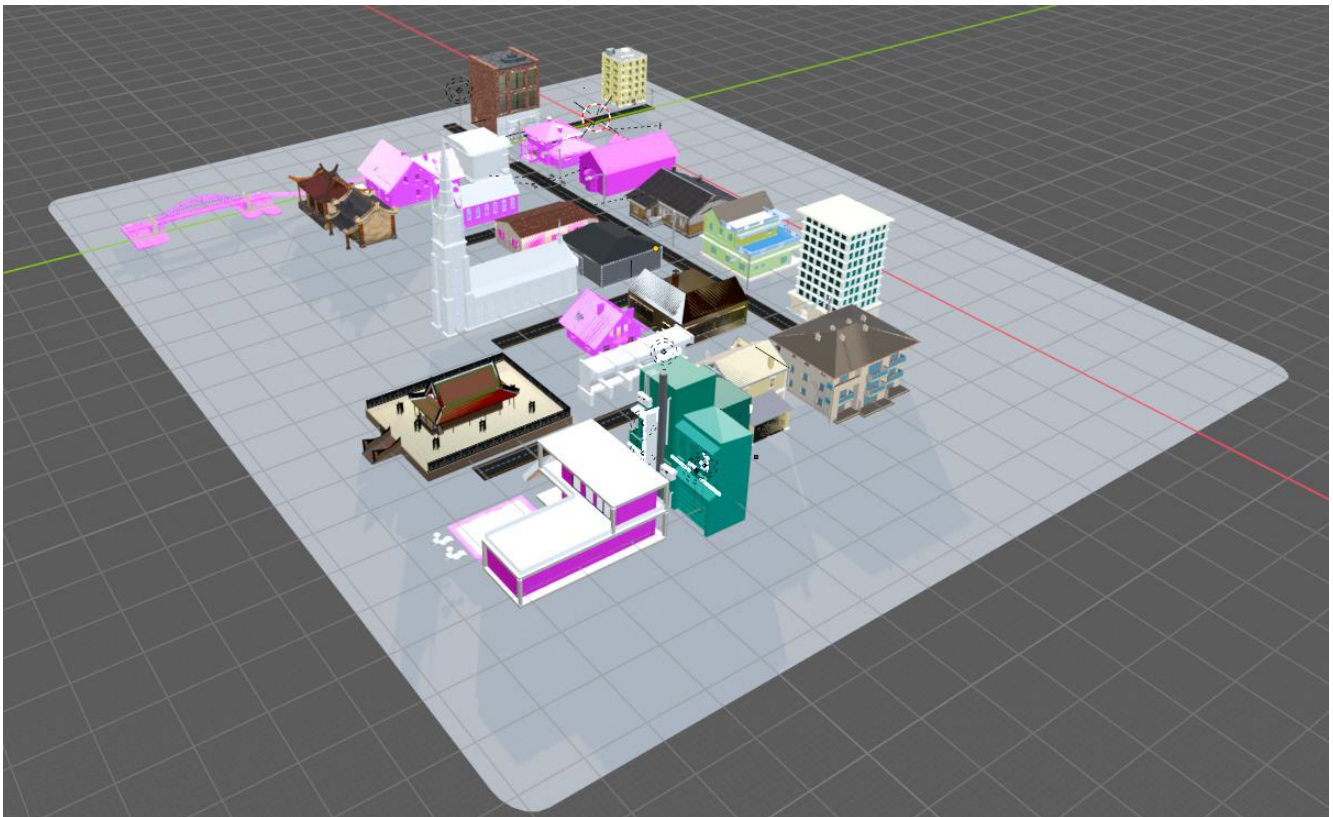

Figure 1. Metaverse model of a multicultural urban environment.

The efficiency of the metaverse-based lessons was evaluated through small group testing, analyzing the efficiency using the E1/E2 criterion (80/80 and improving the lessons based on the analysis.

3.3.2 Data Collection Instruments

Scales for measuring social attitudes, social consciousness, and critical thinking skills were developed to assess the impact of multicultural learning in the metaverse.

The development process includes:

- Studying relevant theories and research and defining the operational definitions of the variables to be measured.
- Creating test items based on the operational definitions.
- Determining the scoring criteria.

The quality of the research instruments was evaluated through content validity. The instruments were reviewed by 3 experts and the Index of Item-Objective Congruence (IOC) was calculated. Items with IOC values of 0.5 or higher were selected.

Reliability: The scales were pilot-tested with a group of 30 students similar to the target sample and the Cronbach's alpha coefficient was 0.87.

3.4. Experimental Procedure

Experimental Group: Students learnt through a metaverse platform designed for multicultural learning for 8 weeks (e.g., cultural exploration activities, role-playing, discussion and reflection and collaborative projects).

Control Group: Students learnt using the regular method without the use of metaverse technology.

Figure 2 illustrates the exploration of different cultures within the metaverse.
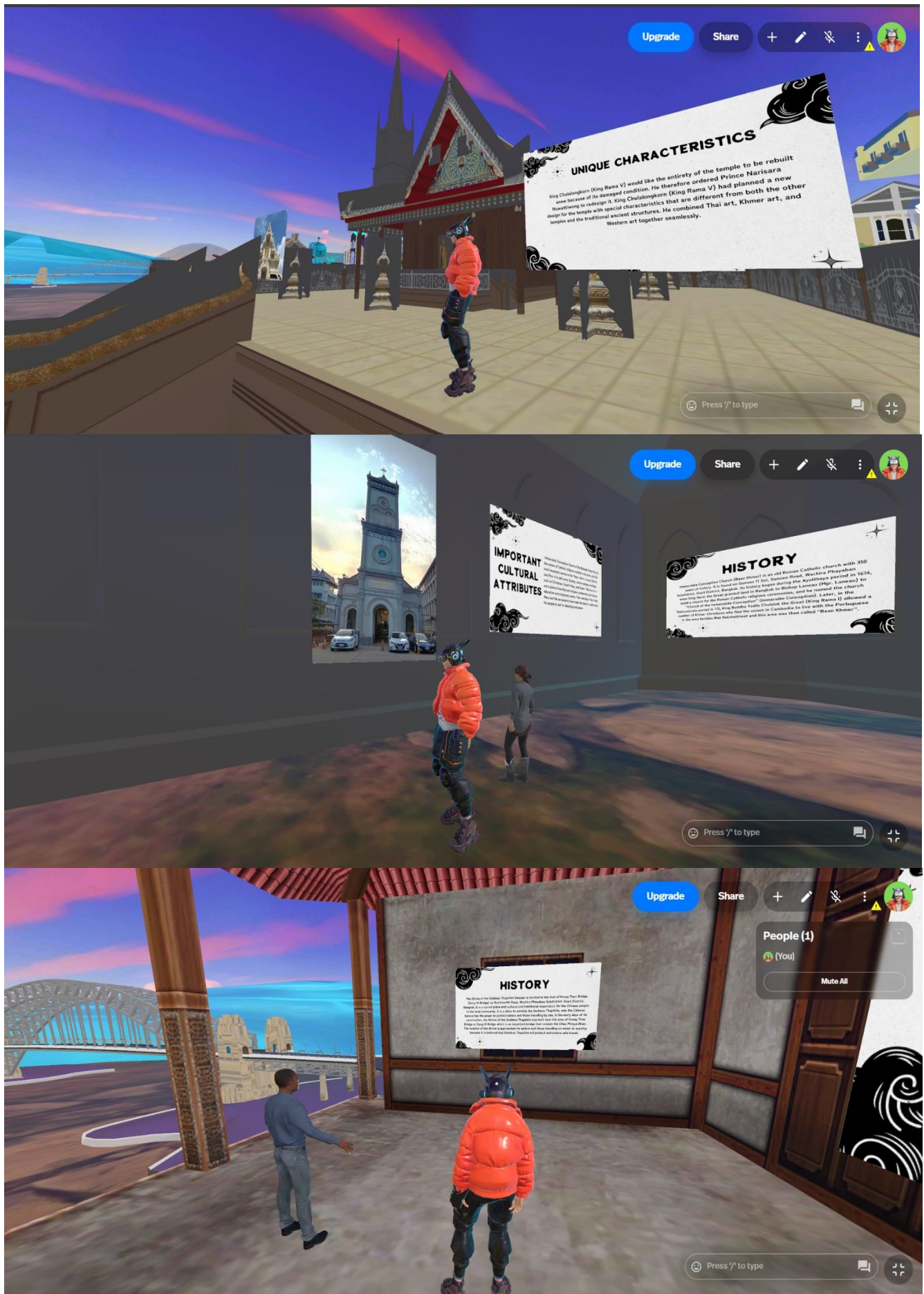
Figure 2. Explore different cultures in the metaverse.

The metaverse-based learning activities were designed to promote the desired skills and attitudes. Table 2 presented activities and processes for multicultural learning in the metaverse.
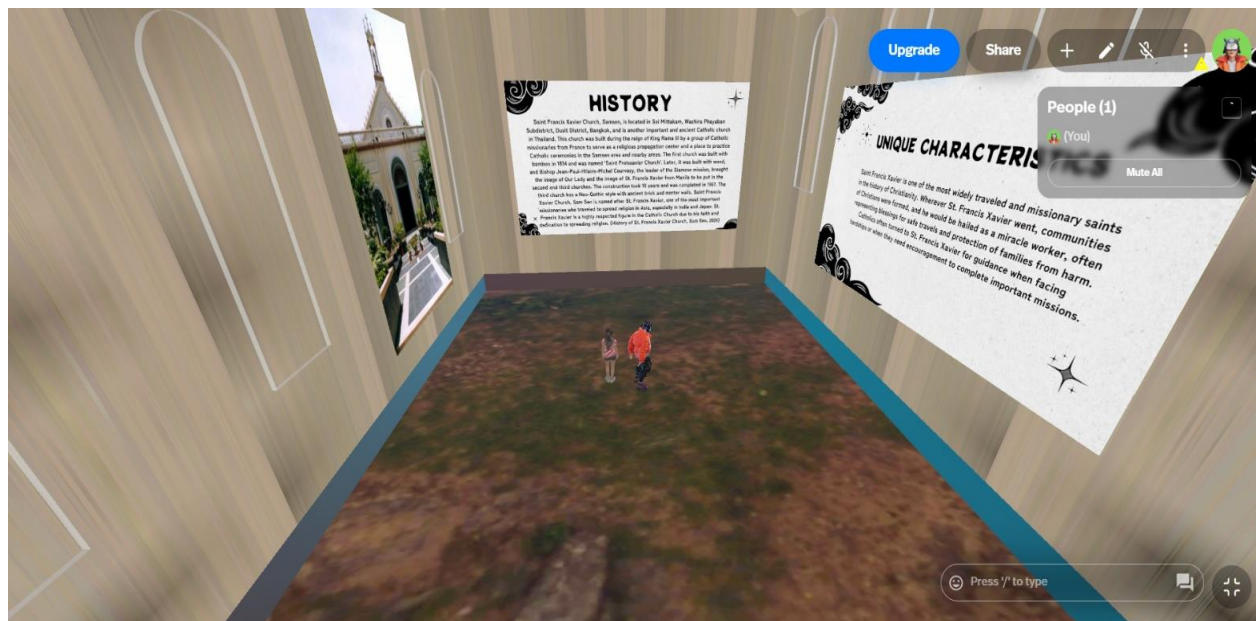
Table 2. Activities and processes for multicultural learning in the metaverse.

Activities	Process
Cultural exploration in the metaverse	Students explore and interact with simulated environments reflecting different cultures such as visiting virtual villages or cultural museums. Students observe and document the cultural differences they face.
Role-playing	Students take on roles in simulated situations related to living in different cultural contexts such as negotiating in a foreign market or participating in tribal rituals. Students learn to adapt and solve problems in unfamiliar cultural settings.
Discussion and reflection	After the metaverse activities, students discuss what they learned and the challenges they faced. Students reflect on their experiences to enhance their understanding of cultural diversity.
Collaborative projects	Students are divided into groups and tasked with creating projects reflecting a specific culture in the metaverse, such as building a virtual cultural space or creating an online cultural exhibition. This activity helps foster teamwork skills and respect for diverse perspectives.

The assessment of knowledge and attitude was conducted before and after the activities to measure changes in attitudes and skills.

3.5. Data Collection
Data were gathered through the administration of pre- and post-tests to both groups. The collection process involved using assessments of social attitudes, social consciousness and critical thinking skills to compare differences in academic achievement.

3.6. Data Analysis
The steps of data analysis are as follows:
First, the characteristics of the participants were analyzed by frequencies and percentages. Second, descriptive statistics were used to analyze the means and standard deviations of the experimental and control groups. Finally, the t-test (independent t-test) was used to compare the mean scores between the experimental and control groups.
Institutional Review Board Statement: The Ethical Committee of Suan Dusit University, Thailand approved this study on March 07, 2024 (Ref. No. SDU-RDI-SHS 2024-019).
(SDU-RDI-SHS: Suan Dusit University - Research and Development Institute –Science, Humanities and Social Sciences).

4. Results
The research results indicate that the pre- post-test scores and learning progress scores of students in the experimental group and the control group (individual level) are shown in Figure 3.
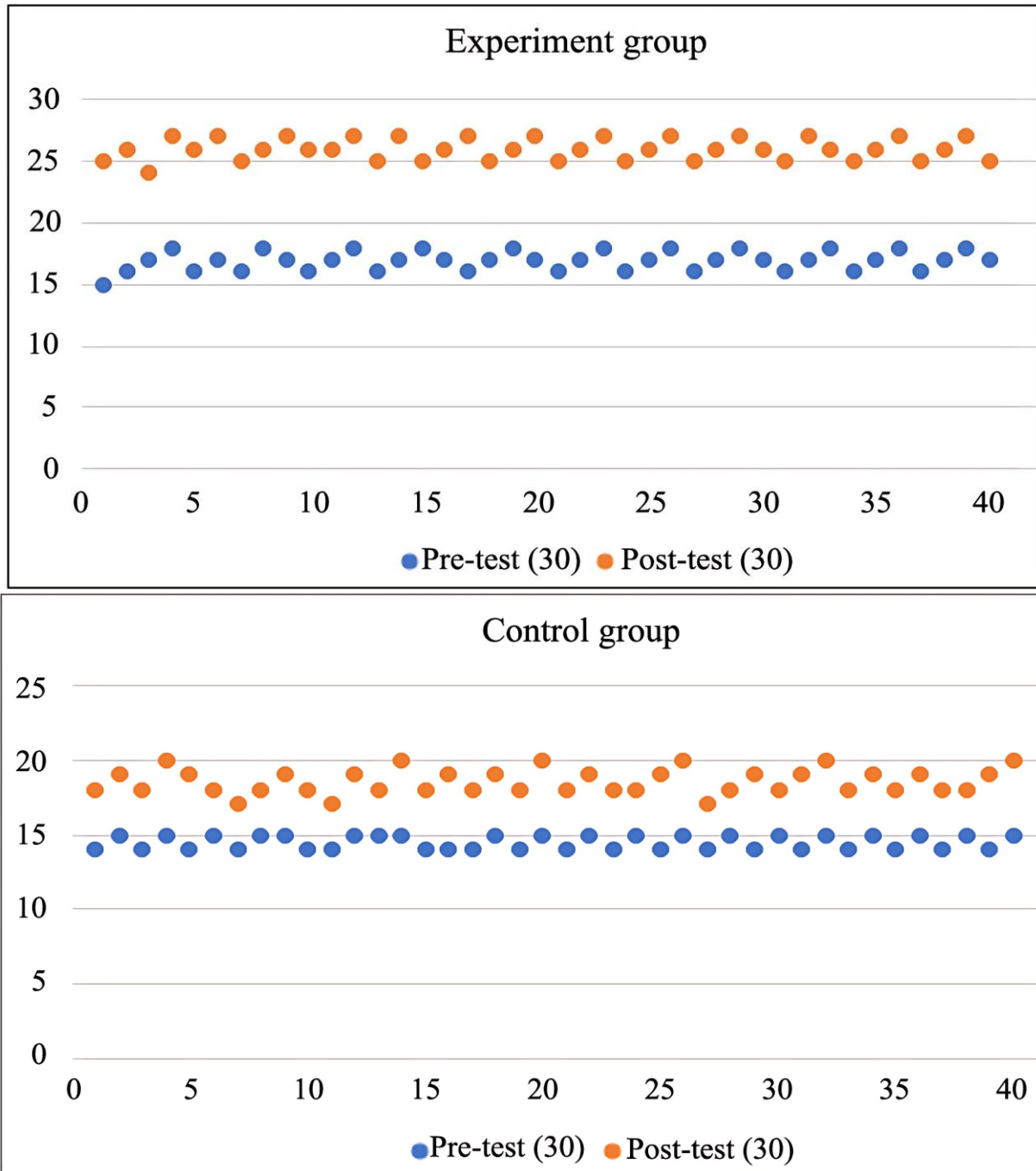
Figure 3. The pre- and post-test scores and learning progress scores of students in the experimental and the control groups.

According to Figure 3, the experimental group exhibited an average learning improvement of 9 points whereas the control group demonstrated an average increase of 3.9 points. This suggests that metaverse technology plays a more significant role in enhancing students' learning outcomes in comparison to conventional educational methods.

Table 3. The mean scores of social attitudes, cultural awareness, and critical thinking skills between the experimental and the control groups.

Variables	Experimental group		Control group	
	Mean	Std. deviation	Mean	Std. deviation
Social attitudes	3.88	0.60	2.87	0.33
Cultural awareness	3.83	0.52	3.62	1.02
Critical thinking skills	4.10	0.64	3.69	0.54
Total	3.94	0.57	3.39	0.49

Table 3 compares the mean scores of social attitudes, cultural awareness and critical thinking skills between the experimental and control groups. The experimental group exhibited higher mean scores across all variables. For social attitudes, the experimental group had a mean score of 3.88 (SD = 0.60) compared to 2.87 (SD = 0.33) in the control group indicating a significant improvement. In cultural awareness, the experimental group scored a mean of 3.83 (SD = 0.52) slightly higher than the control group's mean of 3.62 (SD = 1.02). Critical thinking skills also showed a notable increase in the experimental group with a mean of 4.10 (SD = 0.64) compared to 3.69 (SD = 0.54) in the control group. The total score which summarizes all variables further highlighted the experimental group's overall higher performance with a mean of 3.94 (SD = 0.57) compared to 3.39 (SD = 0.49) in the control group.

Table 4 presents a comparison of the mean scores between the experimental and the control groups.

Table 4. Comparing the mean scores between the experimental and the control groups.

Variables	Test description	F	Sig.	t	Df	Sig. (2-tailed)
Social attitudes	Equal variances are assumed.	5.535	0.021	9.419	78	0.000*
	Equal variances are not assumed.	-	-	9.419	61.045	0.000*
Cultural awareness	Equal variances are assumed.	1.370	0.245	1.136	78	0.259
	Equal variances are not assumed.	-	-	1.136	57.768	0.261
Critical thinking skills	Equal variances are assumed.	0.114	0.737	3.130	78	0.002*
	Equal variances are not assumed.	-	-	3.130	75.749	0.002*
Total	Equal variances are assumed.	0.704	0.404	4.592	78	0.000*
	Equal variances are not assumed.	-	-	4.592	76.340	0.000*

Note: * $p < 0.05$.

The t-test results revealed significant differences between the experimental and control groups in several key areas. Social attitudes showed a notable improvement in the experimental group with a significant t-test result ($t = 9.419$, $p < 0.001$) indicating a strong effect of the intervention. Critical thinking skills also improved significantly in the experimental group ($t = 3.130$, $p = 0.002$). However, no significant difference was found in cultural awareness ($t = 1.136$, $p = 0.259$) suggesting that the intervention did not impact this variable. The total score encompassing all measured variables showed a highly significant difference ($t = 4.592$, $p < 0.001$) confirming the overall effectiveness of the intervention in improving participant outcomes. The overall effectiveness of the intervention is supported by the significant total score difference ($p < 0.001$) between the experimental and control groups.

5. Discussion

This research investigates the effects of metaverse technology on multicultural education, social attitudes, awareness, and critical thinking abilities among secondary school students. The findings reveal notable disparities between the experimental and control groups across various pertinent issues.

The findings indicate that students using metaverse technology demonstrated greater advancements in their learning outcomes compared to their counterparts in traditional classroom settings. The experimental group exhibited an average score increase of 9 points in contrast to a 3.9-point increase observed in the control group. This outcome aligns with the research conducted by which investigated the application of metaverse technology within the domains of Science, Technology, Engineering and Mathematics (STEM) to enhance critical thinking skills. Their study revealed that the experimental group achieved an average score of 85.77 points surpassing the control group's average of 79.52 points resulting in a difference of 6.25 points. Statistical analysis confirmed that the average scores between the experimental and control groups were significantly different. Consequently, the integration of metaverse technology in educational practices facilitates more effective student learning and enhances the comprehension of social studies content compared to conventional instructional methods.

The second issue pertains to the variable of critical thinking skills within the experimental group which exhibited the highest mean level followed by social attitudes and environmental conservation behavior, respectively. The findings of the research indicate that students who engaged in activities exploring diverse cultures within the metaverse interacted with peers to participate in various activities derived from simulated scenarios. They analyzed and identified solutions to experience problems, reflected on their experiences, and exchanged insights gained from these activities. This engagement also facilitated learners' abilities to communicate and collaborate effectively with others. The results underscore the potential of metaverse technology in virtual learning environments demonstrating its efficacy in transmitting information and educational media (Hasanah, Astra, & Sumantri, 2023). These findings align with those of Said (2023) who noted that the integration of the metaverse into the learning process enhances the organization of activities and bolsters students' intellectual skills, including analytical thinking, problem-solving, and collaboration. Furthermore, research conducted by Kye, Han, Kim, Park, and Jo (2021) supports the notion that interactive virtual environments foster increased learner participation in problem-solving activities. Nonetheless, the effectiveness of teaching and learning within a virtual environment may yield varying outcomes based on the educational level and the specific context of the educational institution.

The third issue examined the variables of social attitudes and critical thinking skills in relation to the utilization of metaverse technology, which were found to be statistically significant across both domains. The findings of the research indicate that the implementation of metaverse technology positively influences the social attitudes of participants in the experimental group. Learners engaged with multicultural content within a virtual environment that facilitated their acclimatization to a culturally diverse setting by integrating fundamental information derived from shared learning experiences. This aligns with the findings of Pradana and Elisa (2023) who demonstrated that the virtual environment provided by the metaverse enhances cultural understanding and mitigates cultural bias among students. Furthermore, the outcomes of cultural exploration activities conducted within the metaverse corroborate the assertions of Mystakidis (2022) who posited that the virtual world offers students a more engaging learning experience compared to traditional classroom instruction. Additionally, the research conducted by López-Belmonte, Pozo-Sánchez, Moreno-Guerrero, and Lampropoulos (2023) supports the notion that the virtual environment fosters increased cultural understanding and social awareness, with statistically significant differences observed. The statistical results indicate that metaverse technology possesses the potential to promote analytical thinking, thereby improving learners' problem-solving capabilities regarding the enhancement of analytical thinking skills.

The variable social consciousness, specifically awareness exhibited only a minimal difference between the experimental and control groups with statistical analysis indicating that this difference was not statistically significant. The findings of this research indicate that the metaverse learning environment is highly effective in enhancing students' social attitudes and critical thinking skills within a multicultural educational context. Markowitz, Laha, Perone, Pea, and Bailenson (2018) reported significant advancements in fostering environmental

awareness through virtual experiences. The current study suggests that behavior modification may necessitate more focused interventions. This aligns with the conclusion drawn by Maksl and Young (2023) who asserts that changes in environmental behavior require sustained engagement in real-world contexts alongside virtual learning experiences. Furthermore, the study demonstrated that an integrated pedagogical approach encompassing cultural exploration, simulations, role-playing and collaborative projects was particularly effective in enhancing students' learning outcomes.

6. Conclusion

The implementation of metaverse technology in educational settings has demonstrated remarkable effectiveness in enhancing student learning outcomes as evidenced by our comparative study between experimental and control groups. This research reveals compelling findings across multiple dimensions of student development and learning achievement. This study examined the effectiveness of metaverse technology in educational settings compared to traditional teaching methods. The findings revealed the following three key outcomes: first, students using metaverse technology demonstrated significantly higher learning improvement compared to those in traditional classrooms indicating superior educational effectiveness of the technology. Second, the study found notable improvements in the following two critical areas: social attitudes and critical thinking skills where the metaverse group showed statistically significant advantages. However, cultural awareness showed only minimal differences between the groups. Third, the overall assessment conclusively demonstrated that metaverse technology enhanced student learning outcomes across most measured variables suggesting its potential as an effective educational tool. In conclusion, the research strongly supports the integration of metaverse technology in education particularly for developing higher-order thinking skills and social competencies.

7. Suggestions and Implications

7.1. Suggestions

It is recommended that further research be conducted to examine the application of metaverse technology across various educational contexts and grade levels based on the findings regarding the implementation of metaverse technology in multicultural education aimed at fostering social attitudes, cultural awareness, and critical thinking skills. Such studies should aim to investigate effective instructional strategies that promote learner development. Researchers are encouraged to undertake longitudinal studies that encompass a range of geographic and cultural settings, employing a mixed-methods approach to capture both quantitative and qualitative dimensions of student learning and engagement. Emphasis should be placed on the creation of comprehensive assessment tools capable of accurately measuring multicultural learning outcomes. Additionally, research should address issues of access and equity to ensure that metaverse-based learning environments can adequately support diverse student populations while considering potential disparities in digital access.

7.2. Limitations

Several significant limitations must be acknowledged regarding the implementation of metaverse technology in multicultural education. Firstly, the study was conducted with a sample size of only 80 students from both Dusit and non-Dusit areas in Bangkok which restricts the generalizability of the findings to other educational contexts and regions. Secondly, the 8-week duration of the study may be insufficient for evaluating long-term learning outcomes and the results observed may be influenced by the novelty effect associated with the introduction of new technologies. Moreover, technical considerations such as access to requisite hardware and infrastructure have not been thoroughly examined which may present challenges for the practical application of this technology in educational settings.

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