Chapter # 17

EFFECTS OF VIRTUAL REALITY COLLABORATIVE LEARNING USING A GIANT MAZE ON SOCIALITY AND LEARNING

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ABSTRACT
In this study, two experiments examined the effects of collaborative virtual reality (VR) learning on sociality and learning outcomes using a giant maze. In Experiment 1, differences between VR/Head Mounted Display (HMD) and VR/desktop conditions were evaluated using the same collaborative learning task. Experiment 2 compared cooperative learning with competitive learning using the same VR learning material. Participants in Experiment 1 included 24 female students, whereas Experiment 2 involved 54 students. Participants, paired for the task, navigated a giant maze in the VR collaborative learning material "ayalab Shall we walk?" with a 10-minute completion time. In Experiment 1, participants were randomly assigned to either the VR/HMD condition (META Quest 2 headset) or the VR/desktop condition (iPad 9th generation) in individual small laboratories. In Experiment 2, participants experienced one learning activity, either VR competitive or cooperative learning activities, using an iPad. Group cohesion, the Interpersonal Reactive Index, and critical thinking attitudes were measured before and after the sessions using Microsoft Forms. Experiment 1 showed differing learning effects between VR/HMD and VR/desktop conditions, whereas Experiment 2 demonstrated varied effects between VR cooperative and competitive learning environments. These findings are discussed in detail in this chapter.

Keywords: cooperative learning, competitive learning, VR/HMD and VR/desktop, sociality, giant maze.

1. INTRODUCTION

Recently, various educational materials have been developed utilizing virtual reality (VR) technology (Thompson, Wang, Roy, & Klopfer, 2018). VR technology offers multiple advantages relevant to this study, including experiencing another individual's perspective by wearing an avatar, working on empathy rather than real-life experience (Cotton, 2021), increasing intrinsic motivation (Bailenson, 2018), and facilitating collaboration (Ademola, 2021). In this study, we developed a giant maze in a virtual space to examine the effects of VR collaborative learning utilizing VR/Head Mounted Display (HMD) or VR/desktop (Experiment 1) and to clarify the abilities fostered during VR cooperative or competitive learning in pairs (Experiment 2).

There are three primary types of VR applications: CAVEs (laboratory for experiencing virtual reality), VR/HMDs, and VR/desktop devices. Among these, VR/desktop is the most familiar and accessible, utilizing a PC, an iPad, or an iPhone. A review of prior studies indicated that the educational effects of VR vary depending on the method utilized (Hsu & Wang, 2021). As CAVEs are rarely utilized in educational settings and tablets are distributed to all elementary and junior high schools in Japan, this study focused on comparing VR/HMD and VR/desktop in a collaborative learning context in Experiment 1.

Collaborative learning is generally considered an active learning method, where learners participate actively. In this study, students used avatars in a virtual space to work together (VR cooperative learning), leveraging interactivity and collaboration, which are the strengths of VR technology (Ademola, 2021). While prior studies have not specifically examined cooperative learning utilizing VR, research has found that playing VR cooperative games enhances social skills in high-functioning children with autism aged 10–14 years (Ke & Moon, 2018) and native English-speaking children aged 7–11 years (Craig, Brown, Upright, & DeRosier, 2016). Additionally, VR perspective-taking (VRPT), wherein users adopt another individual's perspective through avatars, has been confirmed by several studies (Herrera, Bailenson, Weisz, Ogle, & Zaki, 2018; van Loon, Bailenson, Zaki, Bostick, & Willer, 2018). Indeed, conducting moral dilemma discussions using VR technology can increase scores in perspective-taking (PT) on the Interpersonal Reactivity Index (IRI) (Fujisawa, 2023), and experiencing moral dilemmas in virtual space can decrease utilitarian judgments (Francis et al., 2016). Fujimoto, Fujisawa, and Murota (2024), who used L'émisérable as a subject for pairs and performed virtual reality role-playing, found that fantasy (FA) scores, which are part of IRI, increased.

The present study compared VR cooperative learning and VR competitive learning utilizing a giant maze. Both learning activities required participants to navigate a maze as quickly as possible. To conquer the maze, participants could utilize strategies such as climbing a steel tower to view the route from above (but reducing the time allotted), checking their current location with various items in the maze, and estimating their position from an overhead perspective. In the VR cooperative learning condition, pairs need to cooperate with each other, remain alert, and strategize to escape from the giant maze more quickly. Conversely, in the VR competitive learning condition, participants do not need to cooperate or think about others; however, they need to think and strategize on their own to reach the goal as quickly as possible.

Meanwhile, there is some debate about the educational effects of competitive and cooperative learning. Fujisawa (2024) developed a VR moral education material that enables participants to enjoy cleaning up the classroom and compared competitive learning with cooperative learning. The results showed that participants were less likely to forget to clean up (higher learning performance) under the competitive learning condition followed by cooperative learning, compared to doing so under cooperative learning followed by competitive learning. Xu, Read, and Allen (2023) developed a video game in which participants played a game wherein they had to rescue a princess, and made comparisons between control, competitive learning, and cooperative learning groups. The results showed that the competitive and cooperative learning groups had higher learning performance than the control group; however, there was no significant difference between the competitive and cooperative learning groups. In statistical learning, individual, competitive, and cooperative learning were compared (Si, Chen, Guo, & Wang, 2022). The results showed that the competitive and cooperative learning groups learned faster than the control group in terms of general learning. Regarding statistical learning, the competitive learning group performed better than the other two groups at the beginning of learning; however, at the end of learning, there was no significant difference among the three groups.

Thus, the findings on competitive and cooperative learning are mixed, and few studies have utilized VR technology. Therefore, it is worthwhile to investigate this knowledge gap further.

Berkowitz and Gibbs (1983) analyzed college students' utterances in moral discussions and identified two types of utterances: operational transactions, which influence participants' thoughts regarding each other, and representational transactions, which do not. The former speech enhances morality. In non-VR paired games, Ilten-Gee and Hilliard (2021) found an increase in operative transactions. In VR cooperative learning, both transaction types occur, whereas in VR competitive learning, neither type is present. However, participants in the VR competitive learning condition would not use the social skills required for cooperation but instead would use different skills of solving and thinking alone.

Based on the above, this study compared VR/HMD and VR/desktop (Experiment 1) and VR cooperative and competitive learning (Experiment 2) utilizing a giant maze to clarify which social and learning skills are fostered in each condition.

2. EXPERIMENT 1

Utilizing the giant maze "ayalab Shall we walk?," Experiment 1 compared VR/HMD and VR/desktop in cooperative learning circumstances to clarify the types of socialities and learning outcomes fostered in each cooperative learning environment.

2.1. Methods

2.1.1. Participants

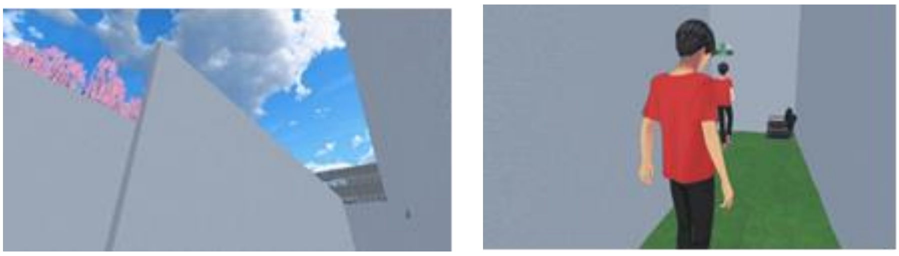
The participants comprised 24 female university students and undergraduate students (age range: 19–26 years). Among them, five had never utilized VR, eight had utilized VR two or three times, and 11 had utilized VR multiple times. They participated in pairs with friends.

2.1.2. Development of the Virtual Space

Prior to this study, the VR collaborative learning material, "ayalab Shall we walk?" was developed using a cluster, metaverse platform. This virtual space enables visitors to stroll through a vast site that changes depending on the four seasons, designed to be universally accessible. Originally, this virtual space was developed to enable truant children and their teachers or counselors to enjoy conversations while taking a slow walk in the virtual space and to ease an individual's expression of feelings in the form of an avatar. This study was conducted in the winter area. The maze was located on a flat surface and was made of white walls. The maze had an entrance (Figure 1) and it consisted of several paths and cul-de-sacs (Figure 2), having only one exit. The ceiling was not covered, and the sky could be seen from inside the maze (Figure 2). The maze had different chairs, sofas, stuffed animals, and so on, which were placed in various locations (Figure 2). There was a steel tower on the upper floor of the entrance to the maze (Figure 1) for participants to climb and observe the maze from above. The decision to climb the tower and observe the maze from above depended on the participants. However, the observation time was within the time limit of the maze (10 minutes). During the experiment, participants could determine their current position and whether it was the first time they had passed through the maze by looking at it from above as well as taking note of various items placed irregularly along the maze (Figure 2).

Figure 1.
Maze entrance and steel tower above the entrance to allow observation of the maze passageways from above.

Figure 2.
Examples of clues in the sky visible from the passageway of the maze (left side) and items placed in the passageway of the maze (right side).



2.1.3. Procedure

The pairs of participants were randomly assigned either to the VR/HMD condition (utilizing Meta Quest 2) or the VR/desktop condition (utilizing a 9th generation iPad). Both groups were informed of the rules of VR cooperative learning as follows: (1) enter the maze from the entrance (Figure 1), (2) reach the maze goal together as a pair, and (3) complete the maze as quickly as possible. Each pair had 10 minutes to complete the maze in the virtual space. Participants in the VR/HMD condition entered individual small experimental rooms where they were assisted by the experimenter in fitting a VR headset and handles, ensuring they understood how to operate the equipment. Participants in the VR/desktop condition similarly entered individual small experimental rooms to confirm that they knew how to operate the iPad. In both conditions, participants were alone in their small laboratories but had online access to converse with each other and the experimenter. During the VR cooperative learning session, the experimenter observed each pair without interference, noting their discussions and recording the avatar’s behaviors. Before and after the experiment, participants completed a questionnaire using Microsoft Forms.

2.1.4. Survey Contents

Eight items from the Attitude toward Groups Scale (Evans & Jarvis, 1986) were utilized to measure group cohesion. The items were scored on a 5-point scale, with 1 = “not applicable” and 5 = “applicable.” The Cronbach’s alpha coefficient was .96. The short version of the Critical Thinking Attitude Scale (Kusumi & Hirayama, 2013) was used to measure critical thinking attitudes. It comprises four subscales: awareness of logical thinking, inquisitiveness, objectivity, and emphasis on evidence. Each subscale comprises three items scored on a 5-point scale, with 1 = “not applicable” and 5 = “applicable.”

The Interpersonal Reactivity Index (IRI; Davis, 1983) was used to measure empathy utilizing four subscales: PT, FA, empathic concerns (EC), and personal distress (PD). Each subscale comprises seven items scored on a 4-point scale, with 1 = “not applicable” and 4 = “applicable.” This scale has been utilized in prior VRPT studies (e.g., Herrera et al., 2018; van Loon et al., 2018).

2.1.5. Scoring

The time taken from the start of the maze to the goal was measured.

2.1.6. Categorization

Pairs of participants who climbed the tower at the start of the maze and observed the maze from above were assigned the term “observed,” while those who did not were assigned “not observed.” Those who reached the goal within the time limit were assigned “task-completed,” and those who could not reach the goal were assigned “task-incomplete.”

2.2. Results and Discussion

Six participants completed the task in the VR/HMD condition, while six did not. In the VR/desktop condition, eight participants completed the task, and four participants did not. Among those in the VR/HMD condition, four participants climbed the steel tower above the maze entrance and observed the layout from above, while eight did not. Similarly, in the VR/desktop condition, four participants chose to observe it from above, and eight did not. A direct probability computation method revealed no significant disparities between condition (VR/HMD, VR/desktop) and task completion (completed/incomplete). The time required to reach this goal was analyzed as follows: 511.0 (0.0) seconds for completed tasks with observation in the VR/HMD condition, 425.8 (45.7) seconds for completed tasks without observation in the VR/HMD condition, 369.0 (0.0) seconds for completed tasks with observation in the VR/desktop condition, and 450.0 (9.2) seconds for completed tasks without observation in the VR/desktop condition.

Basic statistics for the measures adopted in the pre and post-tests are presented in Tables 1 and 2. A three-factor analysis of variance was conducted for group cohesion, IRI subscales, and critical thinking attitude subscales: survey timing (pre-test, post-test), condition (VR/HMD, VR/desktop), and task (completed, incomplete). The findings revealed a significant main effect of the survey timing on group cohesion ($F(1, 20) = 5.0$, $p < .05$, $\eta^2 = .20$), indicating more enhanced group cohesion in the post-test than in the pre-test across both conditions. This suggests that participants felt more connected to their partners after engaging in VR cooperative learning, even without direct face-to-face interaction. There were no significant differences between the VR/HMD and VR/desktop conditions, suggesting that cooperative learning enhances group cohesion even when there are differences in the immersiveness of the tools.

Table 1.
Basic statistics for group cohesion and subscales of Interpersonal Reactivity Index (IRI) (Experiment 1).

			Group cohesion		IRI perspective-taking		fantasy		empathic concern		Distress	
			M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
pre-	VR/	complete	34.0	6.7	21.7	1.6	21.8	3.3	22.5	3.7	19.5	5.5
test	desktop	not complete	34.2	4.6	19.0	2.3	23.3	3.3	18.2	5.1	15.3	5.0
	VR/	complete	36.8	2.7	21.8	1.5	24	3.1	21.1	1.8	18.6	5.9
	HMD	not complete	38.5	0.6	21.0	0.8	21.5	4.5	22.8	1.5	17.3	4.2
post-	VR/	complete	37.0	3.1	24.2	2.7	22.0	4.6	23.5	3.9	19.0	5.9
test	desktop	not complete	37.5	2.9	19.8	2.3	24.0	2.9	18.0	5.1	14.8	5.2
	VR/	complete	38.4	1.6	22.0	1.7	23.6	2.6	21.5	3.3	18.9	5.4
	HMD	not complete	38.0	3.4	23.8	1.3	20.5	4.1	23.3	2.4	16.3	3.4

Table 2.
Basic statistics for critical thinking attitudes (Experiment 1).

			Awareness of logical thinking		Inquisitiveness		Objectivity		Emphasis on evidence	
			M	SD	M	SD	M	SD	M	SD
pre-test	VR/desktop	complete	12.8	1.7	13.0	3.2	12.2	2.0	11.8	3.4
		not complete	11.5	2.2	12.8	1.9	11.5	1.9	9.2	3.3
	VR/HMD	complete	12.1	1.2	12.6	1.3	12.3	2.1	9.6	2.8
		not complete	11.0	1.2	12.3	1.0	11.5	3.0	10.8	1.7
post-test	VR/desktop	complete	13.2	1.5	12.7	3.6	12.2	2.1	11.0	3.8
		not complete	9.3	3.3	13.8	1.0	11.2	1.8	8.0	3.9
	VR/HMD	complete	11.6	1.8	13.0	1.5	12.5	1.9	9.8	2.8
		not complete	9.8	2.9	12.8	2.6	13.8	1.3	10.0	1.6

Regarding IRI, there was a significant interaction effect between the survey timing, condition, and task ($F (1, 20) = 9.3$, $p < .01$, $\eta^2 = .32$). PT scores were higher in the post-test than in the pre-test for completed tasks in VR/desktop and incomplete tasks in both conditions. However, there was no significant change in PT for completed tasks in VR/HMD. This suggests that VR/desktop devices may facilitate the development of PT (Bailenson, 2018;

Herrera et al., 2018; van Loon et al., 2018). This study supports the previous studies (Bailenson, 2018; Herrera et al., 2018; van Loon et al., 2018).

Regarding EC, there was a significant interaction effect between condition and task (F (1, 20) = 4.9, $p < .10$, $\eta^2 = .13$). EC scores increased in the post-test compared with the pre-test for the completed tasks in both conditions, but remained unchanged for completed tasks in the VR/desktop condition. This suggests that VR/HMDs, with immersive 360° 3D capabilities, enhance EC more than VR/desktop devices. No significant differences were found for FA and PD. This may be because this study was a paired maze study, and the participants did not experience fantasizing or feeling the pain of others.

On the Critical Thinking Attitude Scale, there was a significant main effect of task on awareness of logical thinking (F (1, 20) = 9.7, $p < .01$, $\eta^2 = .33$). Post-test scores for awareness of logical thinking were lower when the task was not completed than when it was completed, indicating that task completion status influenced logical thinking skills. This finding underscores the importance of task completion in fostering awareness of logical thinking, regardless of the device utilized. Participants may have judged that, if they could not complete the task, they were not using skills such as awareness of logical thinking.

Finally, for objectivity, there was a significant interaction effect between survey timing and condition (F (1, 20) = 4.8, $p < .05$, $\eta^2 = .20$). Participants may have found it easier to perceive the maze task objectively in the VR/HMD condition than in the VR/desktop condition. This suggests that the immersive nature of VR/HMDs aids in spatial cognitive tasks such as navigating a virtual maze.

These findings highlight the nuanced effects of VR technology on various cognitive and social measures in educational settings, particularly in collaborative learning environments utilizing virtual spaces like mazes. Meanwhile, Experiment 1 had fewer participants and fewer task completers; thus, the findings should be replicated. In addition, the differences between competitive and cooperative learning, as well as the influence of pairs, require analysis.

3. EXPERIMENT 2

This experiment compared VR cooperative learning and VR competitive learning utilizing the VR collaborative learning material, "ayalab Shall we walk?" It also clarified the sociality and learning outcomes fostered in each condition.

3.1. Methods

3.1.1. Participants

The participants included 54 female university students (age range: 18–26 years old).

3.1.2. Procedure

The students participated in the experiment in pairs, with 30 participants randomly assigned to the VR cooperative learning condition (18 opposite-sex paired avatars, 12 same-sex paired avatars) and 24 to the VR competitive learning condition (12 opposite-sex paired avatars, 12 same-sex paired avatars). Questionnaires were administered utilizing Microsoft Forms, before and after the experiment. Participants entered the VR collaborative learning material, "ayalab Shall we walk?" on a cluster platform utilizing a 9^{th}-generation iPad. Along with the experimenter, the participants confirmed the basic operation of the avatar and other functions. The rules of the giant VR maze were then confirmed, namely, (1) always move in pairs in the maze (cooperative learning condition only), (2) enter the maze from the entrance (Figure 1), and (3) reach the goal as quickly as possible. The time limit was set to 10 minutes. In the competitive learning condition, participants were provided with independent virtual spaces of the same content so that they could not follow each other or give each other clues, participating in the experiment without talking to each other or recognizing their competitors in the same laboratory.

3.1.3. Survey Contents and Scoring

Survey contents and scoring were the same as in Experiment 1.

3.2. Results and Discussion

In total, 41 of the 54 participants completed the study within the allotted time. The completion times for the study were as follows: cooperative learning opposite-sex pairs (10 participants) = 483.6 (86.1) seconds, cooperative learning same-sex pairs (10 participants) = 361.2 (157.4) seconds, competitive learning opposite-sex pairs (12 participants) = 292.4 (133.1) seconds, and competitive learning same-sex pairs (9 participants) = 341.1 (143.1) seconds. A two-factor analysis of variance, with learning time as the dependent variable and learning conditions (cooperative learning, competitive learning) and pair composition (opposite-sex pairs, same-sex pairs) as independent variables, revealed a significant interaction between learning conditions and pair composition ($F(1,41) = 4.2$, $p = .047$, $\eta^2 = .10$). Learning tasks were completed more quickly during competitive learning among opposite-sex pairs. The results suggest that competitive learning by male–female pairs may increase learning performance in maze-like learning tasks. The higher learning performance in competitive maze learning is similar to the results of statistical learning (Si et al., 2022). Although the process of learning achievement in both cases may have been similar, the possibility remains that the participants in both cases were college students; therefore, the sense of competition may have been at work.

The basic statistics of group cohesion, IRI, and critical thinking attitudes are exhibited in Tables 3 and 4. A three-factor analysis of variance was conducted with group cohesion, critical thinking attitude subscales, and IRI subscales as dependent variables and the survey timing (pre-test, post-test), learning conditions (cooperative learning, competitive learning), and pair composition (opposite-sex pairs, same-sex pairs) as independent variables.

The main effect of the survey timing was significant for group cohesion ($F (1,50) = 215.9$, $p < .001$, $\eta^2 = .81$). The scores were lower on the post-test than on the pre-test, suggesting that cooperative and competitive learning with VR/desktop reduces group cohesion regardless of the pair composition of the avatars. The result of Experiment 2 contrasted that of Experiment 1. The results of Experiment 2 suggest that learning with pairs in VR may not increase group cohesion regardless of the type of learning. Conversely, Experiment 1 required less time to complete the task than Experiment 2. Thus, the time required for learning together was less. Consequently, it may not have led to increased group cohesion; however, this is not clear from the results of this study.

Regarding IRI, the main effect of the survey timing for PT was significant ($F (1,50) = 5.6$, $p = .02$, $\eta^2 = .10$), and the main effect of pair combination had a significant trend ($F (1,50) = 3.3$, $p = .08$, $\eta^2 = .06$). In both conditions, scores were higher in the post-test than in the pre-test, supporting previous research (Bailenson, 2018; Herrera et al., 2018; van Loon et al., 2018) and Experiment 1. Scores were higher for same-sex pairs than opposite-sex pairs, suggesting that same-sex pairs may be more likely to acquire another viewpoint. For FA and EC, there was a significant trend toward an interaction between the survey timing and learning conditions (FA: $F (1,50) = 3.5$, $p = .07$, $\eta^2 = .07$; EC: $F (1,50) = 9.3$, $p = .01$, $\eta^2 = .16$). Both increased in cooperative learning and decreased in competitive learning. Regarding PD, there was an interaction between the survey timing and the learning conditions, and the pair composition tended to be significant ($F (1,50) = 3.4$, $p = .07$, $\eta^2 = .07$).

Concerning critical thinking attitudes, there was a significant trend for an interaction between the survey timing and pair composition (F (1, 49) = 3.9, p = .05, η^2 = .07). Scores were higher among opposite-sex pairs in both learning conditions. As prior studies have shown, the utilization of VR technology increases intrinsic motivation, which was demonstrated in the opposite-sex pair condition in the present study.

Table 3.
Basic statistics for subscales of Interpersonal Reactivity Index (Experiment 2).

			perspective-taking		fantasy		empathic concern		distress	
			M	SD	M	SD	M	SD	M	SD
pre-test	opposite-sex pairs	cooperative	21.3	2.2	21.1	3.1	20.4	4.2	18.1	5.1
		competitive	21.5	2.4	23.9	3.1	23.3	1.6	20.9	3.5
	same-sex pairs	cooperative	22.3	3.4	22.3	3.6	20.6	2.7	20.3	5.0
		competitive	23.3	3.1	24.0	3.1	23.3	1.7	20.3	3.4
post-test	opposite-sex pairs	cooperative	22.4	2.9	22.3	3.8	21.2	4.6	18.1	5.3
		competitive	21.7	3.5	24.0	2.7	22.8	2.1	20.3	5.0
	same-sex pairs	cooperative	23.0	4.0	22.6	4.7	21.3	2.5	19.8	4.8
		competitive	24.3	4.1	23.0	3.4	22.5	2.2	21.8	3.4

Table 4.
Basic statistics for group cohesion and critical thinking attitudes (Experiment 2).

			Group cohesion		Awareness of logical thinking		Inquisitiveness		Objectivity		Emphasis on evidence	
			M	SD	M	SD	M	SD	M	SD	M	SD
pre-test	opposite-sex pairs	cooperative	34.2	5.9	12.0	2.1	12.4	2.3	11.4	2.3	10.6	3.2
		competitive	35.7	5.1	11.7	1.9	12.3	1.6	11.9	2.4	11.3	2.4
	same-sex pairs	cooperative	37.3	3.7	10.4	3.1	13.5	1.3	12.1	2.2	10.8	2.6
		competitive	34.7	6.0	11.3	1.8	13.2	1.9	13.4	1.7	12.3	1.4
post-test	opposite-sex pairs	cooperative	24.1	1.6	11.4	2.6	12.7	2.4	12.1	1.7	10.2	3.4
		competitive	23.6	1.8	12.3	2.0	13.0	1.5	12.4	2.4	12.3	2.3
	same-sex pairs	cooperative	24.0	1.0	10.8	3.7	13.4	1.6	12.1	3.4	11.1	2.6
		competitive	23.3	1.3	11.2	2.7	13.0	2.6	13.6	1.5	12.3	1.4

4. FUTURE RESEARCH DIRECTIONS

In this study, two points have to be further examined in the future. First, female university students engaged in collaborative participation. In Experiment 2, a male–male avatar pair condition was implemented as a same-sex pair, whereas a female–female avatar pair condition was not established. If conditions that promote cooperative or competitive learning are to be examined, there is still room to consider female–female pair avatars in the future.

Second, in the competitive learning of the study, where each participant used the same maze, learning was completed if one stuck behind the other (escaped from the maze). To prevent this, two independent and identical virtual spaces were set up. In the realistic situation, participants were made visually aware of the presence of competitors in the laboratory. The virtual space used for the experiment was then made independent, creating a learning environment in which participants could not follow (finish) behind the other participant. Thus, at the time when one of the competitors finished learning (escaped from the maze), the other could see who had won—though not during the competition—including how close that individual was to the goal. Therefore, for some participants, it may have been difficult to create a sense of competition until they were informed of their opponent’s goal.

In the future, it is necessary to create two symmetrical skeleton courses in the same virtual space for competitive learning. This would enable visualization of the entire competitive process, as one cannot follow behind the other but can visually recognize how far the other has progressed, thereby learning from each other.

5. CONCLUSION

In this study, the differences between VR/HMD and VR/desktop (Experiment 1) and VR cooperative learning versus VR competitive learning (Experiment 2) were compared utilizing VR collaborative learning materials, examining the social and learning outcomes fostered in each learning.

In Experiment 1, the VR/HMD versus VR/desktop devices were evaluated in a VR cooperative learning setting to assess the skills developed when utilizing each device during the same cooperative learning session. The findings indicated no significant difference in task completion (reaching the goal within the time limit) between the two devices. However, social skills such as empathy and objectivity, which were the focal points of this study, exhibited enhancement in the VR/HMD condition. These findings suggest that immersive 360° devices may facilitate greater learning and social skill development compared with other conditions.

Additionally, the type of social skills acquired may vary not only based on the device utilized but also on whether participants successfully complete the assigned task within the time limit. Therefore, choosing the appropriate device type is crucial depending on the specific skills one aims to cultivate in VR cooperative learning environments.

In Experiment 2, VR cooperative learning was compared with VR competitive learning utilizing collaborative VR learning materials, while also examining the sex composition of cooperative learning pairs (opposite-sex and same-sex pairs). These findings suggest that different learning conditions and pair compositions foster distinct sociality. Consequently, tailoring learning environments to desired sociability outcomes or manipulating conditions strategically may be meaningful. These setups are feasible because of the versatile application of VR technology in creating varied and controlled learning environments.

This study examined the conditions for learning with VR technology that promote targeted sociality and learning outcomes. The results emphasize the importance of considering the type of device (VR/HMD, VR/desktop), gender of the paired avatars, learning conditions (cooperative learning, competitive learning), and task achievement (completed, incomplete) when using VR learning materials.

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