The Role of VR-Supported Co-Learning Environments in University Students' Self-Efficacy and Learning Engagement

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Abstract: The purpose of this study was to investigate the role and impact of technology-assisted co-learning environments on student learning. While virtual reality technology can create realistic learning situations in limited space, peer-supported regulation tasks can promote learning engagement and self-regulated learning. Due to abstract texts often being used in university textbooks and an increase in self-paced distance learning, keeping focused on reading might lead to learning burnout and anxiety. This mode of learning is too monolithic and relies on a high degree of self-discipline while lacking interactivity and affective support. Therefore, this study examined the potential outcomes of VR-supported co-learning environments, including self-efficacy and three types of learning engagement. A total of 46 undergraduate and graduate students were invited to participate in a learning activity where the control group was asked to read the material about collaborative learning concepts on a PDF file, while the VR group was asked to practice regulation skills with a peer via a 2D VR platform, Gather.town, before and after reading the assigned material. Data were collected using a pretest-posttest design and included demographics and self-reports on self-efficacy and learning engagement. Results showed that there was no group difference concerning self-efficacy via the ANCOVA test. However, the VR group was found to report greater affective engagement than the control group with the self-efficacy pre-test held constant. Implications concerning practical contributions to instructional design and the integration of virtual technology into learning were discussed. Future studies are encouraged to create rich and diverse learning opportunities to enhance student's learning self-efficacy and engagement.

Keywords: virtual reality, collaborative learning, learning engagement, peer regulation

1. Introduction

The shift to online and distance learning has gained significance in recent years, especially due to the global pandemic. This has led to the need for effective and engaging virtual learning environments that promote student learning and achievement. Students often struggle to stay focused and engaged when dealing with abstract or resource-demanding texts found in university textbooks, corresponding to subsequent burnout and stress (e.g., Rai et al. 2015). Regulating learning processes, including metacognitive skills like time management (Walczyk et al., 1999) and strategy use (Rai et al., 2011), is crucial in such situations. While research has focused on technology-supported personalized learning (Xie et al., 2019), there is still limited understanding of the effectiveness of social-enabled noveltech environments that combine instructional strategies and technological tools to achieve teaching goals (Parmaxi, 2020).

Technology has increasingly been used to create virtual learning environments that mimic real-world scenarios, providing interactive and collaborative experiences for students (Wang & Sun, 2021). VR-supported co-learning environments offer immersive and interactive learning experiences, while peer-supported regulation tasks encourage students to take ownership of their learning and develop self-regulated learning skills. By working together in an immersive environment, students can learn from each other, share ideas, and provide support, resulting in a more engaging and regulated learning state.

In addition, given the modern learning paradigm emphasizing sociocultural learning (Jonassen et al., 1995; Murphy et al., 2012), it is worth exploring the potential benefits of incorporating co-learning and co-regulated tasks in a virtual reality (VR) setting. While previous studies have investigated the impact of co-learning and co-regulation on student learning (Hadwin et al., 2018; Quackenbush & Bol, 2020), few have examined the effectiveness of using VR technology to enhance these collaborative learning strategies (e.g.,Wang & Sun, 2021, 2022). The use of VR technology in co-learning environments provides immersive peer-interaction experiences that promote active student engagement and foster deeper levels of collaboration between peers. Therefore, this study aimed to investigate the impact of technology-assisted co-learning environments on student learning, particularly to address needs in the context of distance learning. The use of virtual reality platforms such as Gather.town (https://www.gather.town) provides a promising avenue for creating interactive learning experiences that can engage students and promote learning. This study sought to understand the potential outcomes of VR-supported co-learning environments, including self-efficacy and learning engagement, which are critical factors for student success in online and distance learning contexts. The research framework is shown in Figure 1 with the research question outlined as: Are there significant differences in students' self-efficacy and learning engagement between traditional learning and VR-supported co-learning environments?

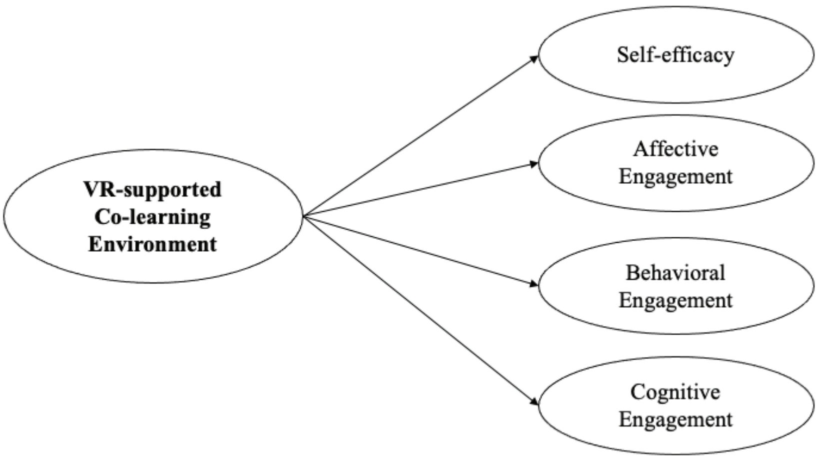

Figure 1. Research Framework

2. Literature Review

2.1 The Social Constructive Dimension for Online/Distance Learning

Distance education is often challenged by isolation and lack of social interaction. Social interaction is essential for human learning as it facilitates the construction of knowledge through dialogue, feedback, and collaboration (Vygotsky & Cole, 1978). Several studies have investigated the importance of social interaction in online and distance learning. For example, a study by Weidlich and Bastiaens (2017) found that learners who perceived a sociable environment experienced greater social interaction that, in turn, explained their satisfaction, confidence, and perceived learning in online courses. Furthermore, interaction among peers using a cloud-based technology application for well-structured collaborative tasks enhanced academic writing scores for those with underdeveloped language skills (Li & Mak, 2022).

The social constructive dimension is especially important for online and distance learning because it enables learners to engage in dialogue and collaboration, which facilitates knowledge construction. As stated by Vygotsky's theory of social constructivism, learning occurs when individuals interact with their environment and with each other (Vygotsky, 1978). Given richer and situated learning experience which novel technology affords, such as VR, learners could benefit from the optimization of sociability, social space, and social presence of the virtual environment to work collaboratively.

2.2 VR-Supported Co-Learning and Co-Regulation

In line with the educational purpose of learning facilitation by technology, virtual reality technology has been increasingly used in peer-learning environments which afford more opportunities for co-regulation and awareness of set goals. Immersive peer-learning environments have been found to promote learning motivation (Wang & Sun, 2022) and emotional engagement (Wang & Sun, 2021). Sun et al. (2023) also found that using wearable hybrid AR/VR materials helps create positive effects on students' situated interest, engagement, and learning performance among high school learners, with similar findings for elementary students using VR-based wearable devices (Hung et al., 2023). However, scarce findings are available concerning various forms of VR tools (i.e., Gather.town) suiting co-learning tasks with the quality determined by individual and group effort to regulate behaviors toward goal attainment.

The self-regulated learning (SRL) model proposed by Zimmerman (2000) is a cyclical process that involves three phases: forethought, performance or volitional control, and self-reflection. In the forethought phase, learners set goals, activate prior knowledge, and develop plans. During the performance phase, learners use strategies to implement their plans and monitor their progress. Finally, in the self-reflection phase, learners evaluate their performance, attribute their successes or failures, and modify their plans for future learning. The structure of regulated-learning practice usually remains the same when more than one person is involved in the process, but the task ownership might depend on the level of individuals' collaborative beliefs and task setting.

Co-regulated and socially-shared regulated learning complement self-regulated learning theory, as they add a new dimension to the regulation of learning influenced by others (Panadero & Järvelä, 2015). Co-regulated learning and socially-shared regulated learning are two related but distinct concepts in the context of learning. Co-regulated learning involves a relationship between individuals where one person is more knowledgeable or skilled, and both parties self-regulate and share regulation of behavior, emotions, motivation, and cognition for personal goal attainment (Hadwin et al., 2018). Socially-shared regulated learning, on the other hand, refers to the joint effort, where the group takes metacognitive control of the task together through negotiation and an iterative process of behavioral, emotional, motivational, and cognitive exchange (Hadwin et al., 2018). As such, regulation of learning in this given context inclines toward the direction addressed by the whole group and away from the members within the group (Järvelä & Hadwin, 2013; Panadero & Järvelä, 2015).

The co-learning environment pinpointed in the present study adopts the notion more related to socially-shared learning, as prompts are provided to assign the leading role of collaborative tasks, involving reading out the instruction and navigating the process of responding to questions. Therefore, the present study builds on prior research by examining the impact of VR-supported co-learning environments on self-efficacy and learning engagement. While prior studies have investigated the impact of collaborative learning on student learning, few have examined the role of VR technology in promoting positive affective states and increasing student engagement. By exploring the relationship between VR-supported co-learning environments and student self-efficacy and engagement, the present study provides new insights into the potential benefits of using immersive technologies to support online education and distance learning.

3. Methods

3.1 Participants

The present study conducted in northern Taiwan utilized a quasi-experimental design and the convenience sampling method to gather information from 46 university students. Both males and females were equally represented in the study (50%) with an average age of 23.90 years (*SD* = 2.57). The majority of the students were pursuing majors related to STEM fields, followed by social sciences. The participants' educational levels comprised undergraduate (*n* = 11) and graduate (*n* = 35) programs.

3.2 Experimental procedure

Figure 2 illustrates the experimental design, where the participants were randomly divided into two groups. Before the experiment, the students were informed about the research and gave their consent. They also responded to the questionnaire consisting of demographics and a self-efficacy self-report. After that, the control group was asked to read PDF material on the computer, while the VR group participated in co-learning tasks on a 2D map situated on the Gather.town conferencing platform (https://www.gather.town), before and after reading the assigned material. The reading time lasted 15 minutes, with an additional 13 minutes for the VR group to complete their co-learning tasks. Afterwards, the participants were asked to complete a semi-structured questionnaire, which took about 6 minutes.

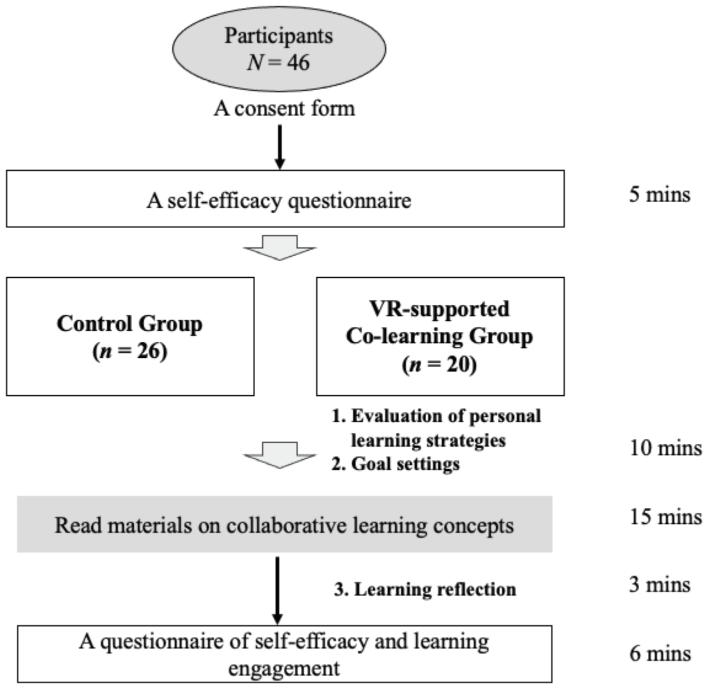

Figure 2. Experimental Procedure

3.3 Instruments

3.3.1 Self-Report Questionnaires

Self-efficacy and learning engagement scales were used in our self-report questionnaires. The *self-efficacy scale* aimed to assess students' confidence in comprehending the reading topic with the version in this study adapted from (Sun et al., 2015). There were eight items on a 6-point Likert scale, with sufficient reliability (α = .95; Nunnally, 1967). In addition, the *learning engagement scale* was translated from Whitney et al. (2019) with expert review, and assessed to what extent students revealed affective, behavioral, and cognitive engagement. The affective sub-dimension consisted of eight items, the behavioral sub-dimension comprised nine items, and the cognitive sub-dimension had seven items on a 5-point Likert scale. The Cronbach's α of each subscale was .89, .78, .80, respectively.

3.3.2 Co-Learning Tasks on the Gather.town Platform

Three co-learning tasks were conducted on the Gather.town conferencing website, which is a virtual platform that provides a customizable and interactive space (see Figure 3) for students to collaborate and learn together. The tasks included evaluation of personal learning strategies, goal setting, and learning reflection, and each task was completed in pairs, with two students working collaboratively. In the evaluation of personal learning strategies task, each pair discussed their learning strategies and identified ways to improve them. In the goal-setting task, the pairs shared their personal goals for their time-limited reading task. Finally, during the learning reflection task, the pairs reflected on their learning progress and identified their goal achievements for the reading and areas for further improvement. The co-learning approach encouraged collaboration between students, and provided an opportunity for them to clarify learning goals with collective effort in a virtual environment. The Gather.town conferencing website facilitated the co-learning process by providing a platform for students to connect and work together, using a variety of customizable features such as virtual avatars, 2D pixel maps, and interactive elements.

Figure 3. Interface on Gather.town

4. Results and Discussion

Several ANCOVA tests were employed to examine between-group differences concerning the outcomes of the self-efficacy ratings and learning engagement ratings (see Table 1). All the analyses were conducted using the IBM SPSS Statistics 24 software. Students' self-efficacy ratings were found to be equivalent across the two groups after controlling for their prior self-efficacy. As for students' ratings of learning engagement by the control of prior self-efficacy, only the affective engagement sub-dimension showed that the VR group reported higher ratings than the control group. No group differences were observed for the behavioral sub-dimension or cognitive sub-dimension.

Table 1
Results of the ANCOVA tests for self-efficacy and learning engagement

Outcomes	*n* = 26 Control group *M (SD)* M_{Adj} *(SE)*	*n* = 20 VR group *M (SD)* M_{Adj} *(SE)*	*F*	*p*	partial η^2
Self-efficacy[a]	4.50 (0.69) 4.48 (0.12)	4.26 (0.68) 4.29 (0.14)	1.09	.303	.025
Learning engagement[a]					
Affective	3.59 (0.75) 3.57 (0.12)	3.94 (0.48) 3.96 (0.14)	4.49	.040*	.095
Behavioral	3.49 (0.50) 3.49 (0.10)	3.67 (0.56) 3.68 (0.12)	1.47	.232	.033
Cognitive	3.69 (0.53) 3.68 (0.10)	3.58 (0.47) 3.86 (0.11)	1.50	.228	.034

Note. * $p < .05$, [a] analysis with the covariate of prior self-efficacy

Despite greater enjoyment and desire of learning collaborative learning concepts found in the VR group as corresponded to previous studies (Slater, 2018), there were a few speculations for the minimal benefit of VR-supported co-learning environments. First, it is difficult to change students' learning styles and behavior with a one-time effort (Wang & Sun, 2021), although students were asked to be more aware of using effective learning strategies and clarifying their goals before their tasks. As such, students might still use maladaptive learning strategies that confound with behavioral or cognitive engagement. In addition, experienced affect in the VR-supported co-learning environment as one of the four sources (i.e., affect, past performance, vicarious learning, and social persuasion) of self-efficacy may not be enough to enhance subsequent self-efficacy (Bandura, 1977).

5. Conclusion

This study aimed to investigate the impact of technology-assisted co-learning environments on student learning. The results showed that only the affective engagement sub-dimension of learning engagement ratings showed a significant difference, with the VR group reporting higher ratings than the control group. There were no significant differences in self-efficacy ratings between the two groups after controlling for prior self-efficacy. The limitations of this study include the possibility that students may still use maladaptive learning strategies that confound with cognitive and behavioral engagement, and the potential inadequacy of the experienced affect in the VR-supported co-learning environment as a source of self-efficacy. Moreover, there may be a lack of statistical power given the small sample size to assess VR-supported co-regulation effects. Future studies should consider a longer timeframe and explore richer and more diverse learning opportunities to enhance student learning in technology-assisted co-learning environments. Nonetheless, this study provides practical implications for instructional design and the integration of virtual technology into learning environments.

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