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Implementation of collaborative project-based learning approach: Spherical video-based virtual reality creation

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Abstract: There have been obstacles for individual students to participate in project-based learning, such as the lack of learning engagement and the frustration of encountering difficulties. Therefore, this study proposed a collaborative project-based learning approach with SVVR technology to enhance students' project-based learning outcomes. A quasi-experimental design was conducted to show the effectiveness of the proposed approach. Two classes students in a university participated in the experiment. On class with 25 students were in the experimental group, and 20 students were in the control group. The experimental group experienced collaborative project-based learning with SVVR, while the control group underwent individual project-based learning with SVVR. The results of this study revealed that the experimental group outperformed the control group in terms of students' computational thinking and the SVVR project quality. This study highlights the effectiveness of collaborative project-based learning in enhancing students' computational thinking and creativity.

Keywords: PBL, SVVR, project-based, creativity, collaborative

1. Introduction

Project-based learning (PBL) has become increasingly popular as a way to adapt to a changing world, and it allows students to learn by doing through a project (Oguz-Unver & Arabacioglu, 2014; Thomas, 2000). This approach has been shown to have a positive impact on students' deep learning and to develop their higher-order skills (Baran et al., 2018; Kızkapan & Bektaş 2017). Despite these benefits, there have been obstacles and skepticism in implementing project-based learning successfully. For example, if the design of a project-based learning activity is not engaging, students may lose focus and waste time during the project (Huang et al., 2023). Additionally, evaluating the results of project-based learning can be challenging, as most assessments are group-based (Loertscher, 2008). To address these challenges, virtual reality (VR) technology is proposed as an alternative solution for project-based learning. This technology can serve as an effective learning medium for both individual and group projects, and it offers a more engaging and immersive experience for students.

Over the past ten years, virtual reality has become a commonly used tool in both research and teaching, particularly in the PBL approach (Won et al., 2022). For instance, a qualitative case analysis conducted by Morales et al. (2013) showed that project-based learning in virtual reality classrooms can be effective, even with minimal teacher guidance, and has great potential for independent and peer-mentored learning. Hou et al. (2023) conducted a project-based learning approach for virtual reality-aided green building education, which demonstrated the effectiveness of this novel approach in delivering green building education. Additionally, Zang et al. (2022) linked project-based learning and semi-immersive virtual reality to improve learning performance, providing valuable insights for educational institutions looking to enhance student performance through project-based learning opportunities.

On the other hand, scholars have pointed out that creating realistic 3D interactive VR content can be expensive and time-consuming, making it difficult for many schools to afford (McFaul & FitzGerald, 2019). Additionally, designing VR content can be challenging for most teachers (Merchant et al., 2014). Furthermore, teachers require user-friendly tools and materials to use as learning resources for PBL (Gerhátová et al., 2021). To address these challenges, spherical video-based virtual reality (SVVR) is an excellent option as it reduces the cost and time required to create VR content. Importantly, creating SVVR content does not require advanced technical skills (Chien et al., 2020), making it a suitable option for students' PBL activities.

To improve students' computational thinking skills and promote innovative thinking in a project, it is essential to encourage teamwork and the exchange of ideas with peers, as suggested by Baser et al. (2017) and Kerimbayev et al. (2023). Vasileva et al. (2011) also support this idea by using project-based collaborative learning in a web-based virtual environment to facilitate synchronous and asynchronous communication among students. Computer-supported collaborative learning (CSCL) environments, as noted by Chan (2012) and Sidek et al. (2020), can assist students in self-regulated learning, sharing ideas, and enhancing their creativity. Therefore, this study proposed a collaborative project-based learning approach with SVVR technology to improve students' computational thinking and creativity. The research questions were proposed as follows:

1. Is there any difference between the SVVR-collaborative project-based learning approach and the SVVR-individual project-based learning approach in terms of the students' computational thinking?
2. Is there any difference between the SVVR-collaborative project-based learning approach and the SVVR-individual project-based learning approach in terms of the students' SVVR project?

2. Literature review

In the rapidly evolving digital era, characterized by rapid technological advancements and an increasing reliance on information technology, computational thinking has emerged as a crucial skill to navigate the complexities of modern life effectively. This cognitive skill encompasses a multifaceted approach to problem-solving, enabling individuals to analyze, and synthesize complex problems into manageable components, ultimately arriving at innovative and efficient solutions (Wing, 2006). Collaborative project-based learning, integrated with SVVR technology, has been identified as a promising approach to foster and apply computational thinking skills among students (Saad & Zainudin, 2022). Engaging in collaborative tasks within virtual environments allows students to practice problem-solving, enhancing their ability to tackle complex challenges in a systematic manner (Esteves et al., 2006). In addition, collaborative project-based learning with SVVR has garnered considerable attention as an effective means to promote deeper learning and teamwork among students (Baran et al., 2018; Kızkapan & Bektaş, 2017).

The integration of SVVR technology into collaborative project-based learning has demonstrated significant benefits, leading to improved computational thinking and creativity among students. The experiences within virtual environments equip students with practical skills and the confidence to apply their knowledge effectively (Hou et al., 2023). Collaborating in SVVR environments fosters creativity by encouraging students to share ideas, explore diverse perspectives, and experiment with innovative solutions (Bilyatdinova et al., 2016; Guan et al., 2023). The nature of SVVR technology provides a fertile ground for students to explore their creative potential and express their ideas through unique content creation (Parmaxi, 2023).

3. Methodology

3.1 Participant

This study adopted a quasi-experimental design, with a total of participants were 45 freshmen in a university. These students were from two classes, which were randomly treated in the experimental group (n = 25) and the control group (n = 20). The experimental group received instruction through a collaborative project-based learning approach with the use of spherical video-based virtual reality, while the control group received instruction through an individual project-based learning approach with the use of spherical video-based virtual reality.

3.2 Experimental procedure

The experimental procedure of this study is shown in Figure 1. Both the experimental and control groups participated in classes and activities that lasted for four weeks, meeting once a week for 100 minutes each time. In the first week, both groups received an introduction to project-based learning activities and SVVR technology to learn how to use the technology, and pre-questionnaire of students' computational thinking. The same instructor taught both groups during the learning activities, and they used the same SVVR app, specifically the iStaging app. The interface of the iStaging app is shown in Figure 2. This application allowed students to practice creating content, designing the interface, organizing information, and sharing their creations. Both groups used the same learning material for two weeks. The learning activities process is shown in Figure 3. The major difference between the two groups was the treatment of student activities (collaborative and individual). For the experimental group, students used a collaborative project-based learning approach with spherical video-based virtual reality. While in the control group, students used an individual project-based learning approach with spherical video-based virtual reality. After that, the teacher gave students a project assignment and a post-questionnaire of students' computational thinking to evaluate the impact of the treatment individually.

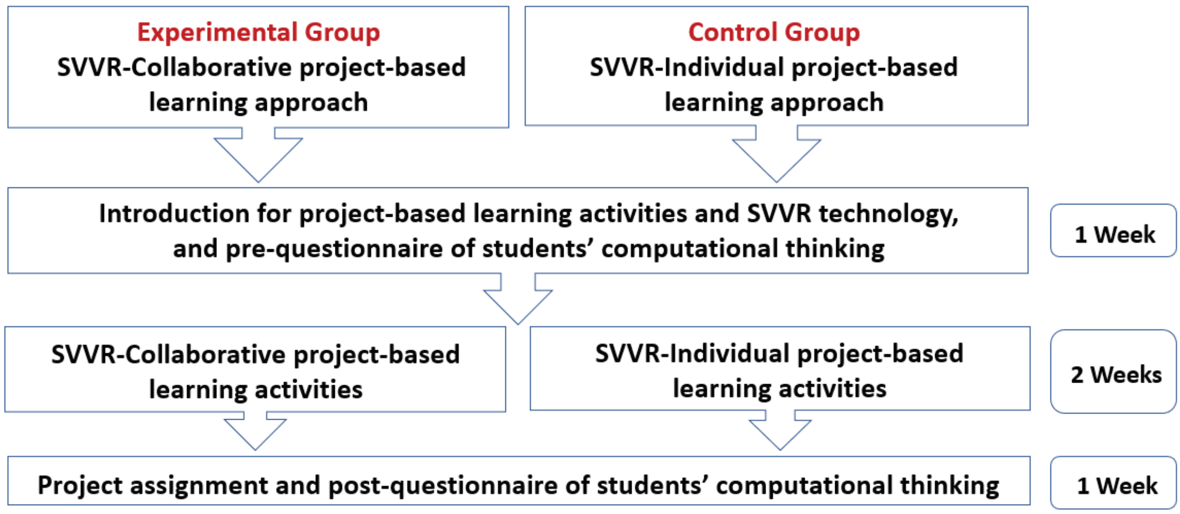

Figure 1. The experimental procedure

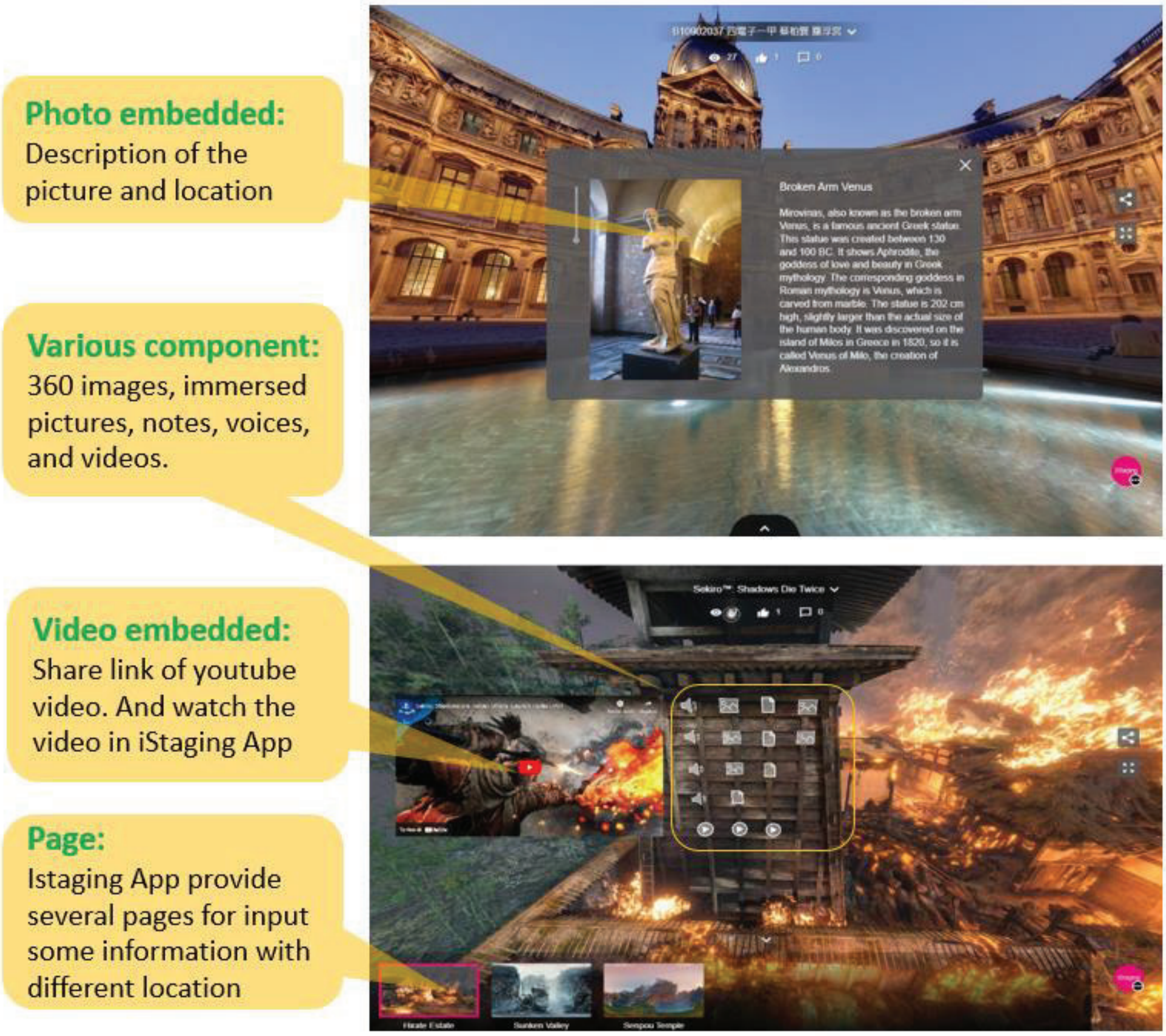

Figure 2. The interface of SVVR in the iStaging app

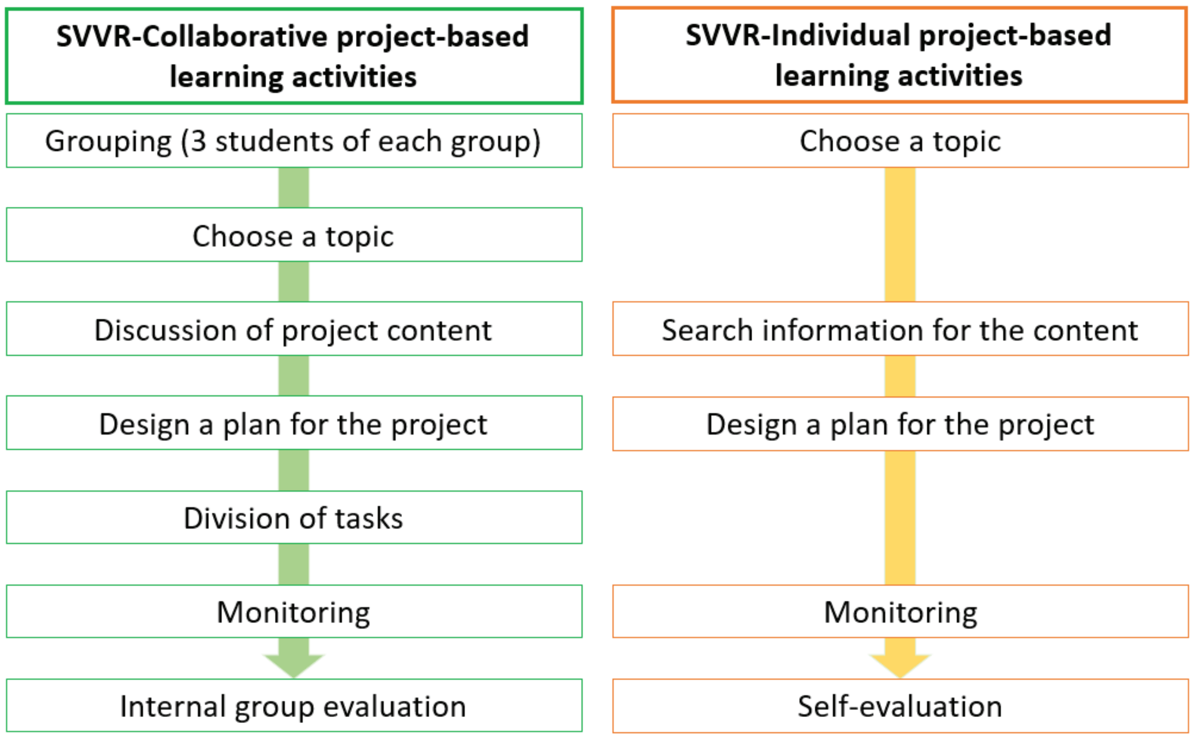

Figure 3. PBL activities process

3.3 Instrument

A questionnaire was utilized to evaluate the students' computational thinking. The item in the questionnaire was presented with a 5-point Likert scale, ranging from 1 as strongly disagree to 5 as strongly agree. The students' computational thinking questionnaire was adopted from Hwang et al. (2020), which consisted of six items with a Cronbach's alpha of .77.

To examine students' SVVR projects, two instructors was developed a rubric by referring to Chang and Hwang (2018), Fegely and Cherner (2021), and Hwang et al. (2018). The rubric consists of four dimensions: content knowledge, complexity, appearance, and creativity, as presented in Table 1. Each criterion is rated on a five-point scale ranging from 0 (lowest) to 5 (highest). The first dimension, content knowledge, evaluates students' ability to provide accurate, detailed, and appropriate information. The second dimension, complexity, measures students' proficiency in using the iStaging app to include various components, such as 360 images, immersed pictures, notes, voices, and videos. The third dimension, appearance, assesses students' ability to organize the content effectively and create a visually appealing layout for easy viewing. Lastly, the dimension of creativity measures students' level of creativity in developing their SVVR projects.

Table 1. *The rubric of SVVR project*

Dimension	Scale				
	1	2	3	4	5
Content knowledge	No information	Simple information, but not appropriate	Lots of information, but not appropriate	Simple and appropriate information	Detailed and appropriate information (such as, video, voice, link, etc.)
Complexity	Only 360 image	Two components (360 image	Three components (360 image,	Four components (360 image,	Five or more components (360 image,

Dimension	Scale				
	1	2	3	4	5
		and immersed picture)	immersed picture, and note)	immersed picture, note, and voice)	immersed picture, note, voice, video, etc.)
Appearance	Uncomfortable to watch and poor layout	Uncomfortable to watch and normal layout	Comfortable to watch, but poor layout	Comfortable to watch and normal layout	Comfortable to watch and good layout with a neat structure
Creativity	The work creativity is extremely poor	The work creativity is poor	The work creativity is mediocre	The work creativity is good	The work creativity is excellent

4. Result

To analyze the prior competence of students' computational thinking in the two groups was used the independent sample t-test, and the result showed that there was no significant level was found ($t = 0.64$, $p > .05$), indicating that the prior students' computational thinking of the two groups was equivalent before the learning activity. Subsequently, a within-group homogeneity regression analysis indicated no significant difference between the two groups ($F = 0.001$, $p > .05$), confirming the homogeneity test passed. Then, Analysis of Covariance (ANCOVA) was employed to analyze the post-questionnaire scores of the two groups by excluding the effect of the pre-questionnaire. Table 2 shows the ANCOVA result. The adjusted scores of the experimental and control groups are 4.25 and 3.71, and the F score is 9.57 ($p < .01$, $\eta^2 = 0.19$), showing a high effect size (Cohen, 1988). Consequently, it was concluded that the students who learned with a collaborative project-based learning approach had significantly better computational thinking than those who learned with an individual project-based learning approach.

Table 2. *The ANCOVA result of computational thinking students*

Variable	Group	N	Mean	SD	Adjusted mean	SE	F	η^2
Computational thinking	Experimental	25	4.26	0.51	4.25	0.12	9.57**	0.19
	Control	20	3.69	0.68	3.71	0.13		

**$p < .01$.

The students' SVVR project score in this study was analyzed by independent sample t-test. For the first dimension, content knowledge, was evaluated using Levene's test of error variance, which showed that the two groups were homogeneous ($F = 0.12$, $p = 0.73 > 0.05$). Table 3 shows the mean and standard deviation for the experimental group were 3.88 and 1.13, respectively, while the mean and standard deviation for the control group were 3.00 and 1.17. A t-test revealed a significant difference in content knowledge dimension between the two groups ($t = 2.56$, $p < 0.05$), indicating that the use of the SVVR-collaborative project-based learning approach improved students' competence in this dimension.

Similarly, for the complexity dimension, Levene's test for error variance showed that the two groups were homogeneous ($F = 1.45$, $p = 0.24 > 0.05$). The mean and standard deviation for the experimental group were 3.76 and 1.01, respectively, while the mean and standard deviation for the control group were 2.90 and 1.45. A t-test showed a significant difference in complexity between the two groups ($t = 2.34$, $p < 0.05$), it means that the use of

SVVR-collaborative project-based learning enhanced students' capability in the complexity dimension.

However, for the appearance dimension, Levene's test for error variance indicated that the two groups were also homogeneous (F = 0.73, $p = 0.40 > 0.05$). The mean and standard deviation for the experimental group were 3.80 and 0.87, respectively, while the mean and standard deviation for the control group were 3.40 and 0.94. A t-test showed no significant difference in appearance dimension between the two groups ($t = 1.48$, $p > 0.05$), suggesting that the use of SVVR-collaborative project-based learning did not significantly enhance students' capability in this dimension.

For the creativity dimension, Levene's test for error variance also showed that the two groups were homogeneous (F = 0.08, $p = 0.78 > 0.05$). The mean and standard deviation for the experimental group were 4.04 and 0.89, respectively, while the mean and standard deviation for the control group were 3.10 and 0.97. A t-test revealed a significant difference in creativity between the two groups ($t = 3.39$, $p < 0.01$), indicating that the use of SVVR-collaborative project-based learning enhanced students' creativity.

When considering the average for all four dimensions, Levene's test for error variance indicated that the two groups were homogeneous (F = 0.09, $p = 0.77 > 0.05$). The mean and standard deviation for the experimental group were 3.87 and 0.87, respectively, while the mean and standard deviation for the control group were 3.10 and 0.98. A t-test showed a significant difference in the average dimension between the two groups ($t = 2.79$, $p < 0.01$), it shows that the use of SVVR-collaborative project-based learning enhanced students' capability in each dimension.

Table 3. *Independent sample t test of students' SVVR project*

Test	Group	N	Mean	SD	t	d
Content knowledge	Experimental	25	3.88	1.13	2.56*	0.76
	Control	20	3.00	1.17		
Complexity	Experimental	25	3.76	1.01	2.34*	0.69
	Control	20	2.90	1.45		
Appearance	Experimental	25	3.80	0.87	1.48	
	Control	20	3.40	0.94		
Creativity	Experimental	25	4.04	0.89	3.39**	1.01
	Control	20	3.10	0.97		
Average	Experimental	25	3.87	0.87	2.79**	0.83
	Control	20	3.10	0.98		

*$p < .05$, **$p < .01$.

5. Discussion and conclusion

This study proposed a collaborative project-based learning approach with SVVR technology to improve students' computational thinking and creativity in SVVR content creation. According to the results of the study, the students' computational thinking and the average dimension of the SVVR project revealed that students in the experimental group have significant differences compared to students in the control group. This shows that the collaborative project-based learning approach can be effective in enhancing productivity and positive feelings in facing challenges (Song, 2018; Spoelstra, 2014) and improve students' computational thinking (Li et al., 2023; Zhou & Tsai, 2022).

The study found a significant difference between the two groups in terms of content knowledge, complexity, and creativity dimensions. This finding supports the previous research indicating that collaborative project-based learning improves students' creativity and communication skills to discuss project ideas (Sidek et al., 2020; Vasileva et al., 2011). To produce exceptional and engaging content, one idea is often not enough, and teamwork is crucial for sharing ideas and complementing each other's strengths. The collaborative project-based learning approach is a way to train students in teamwork and communication, particularly in project creation (Lee et al., 2017).

However, no significant difference was found in the appearance dimension between the two groups. Although the experimental group had a higher score than the control group, researchers consider that the collaborative project-based learning approach did not really affect organizing the layout of the SVVR project. Because the SVVR technology is user-friendly and does not require high-tech capabilities (Chien et al., 2020).

Additionally, to enrich the learning experience further, future studies could incorporate multiple learning strategies in conjunction with collaborative project-based learning. Techniques such as mind mapping, question prompts, and metacognitive strategies have shown promise in augmenting students' critical thinking and problem-solving abilities. By integrating these strategies into the SVVR project creation process, teachers may unlock additional potential for students to tap into their creative thinking and collaborative skills, propelling the learning experience to new heights.

In conclusion, the investigation of the collaborative project-based learning approach with SVVR technology has shed light on its multifaceted benefits. The findings support the notion that this pedagogical approach enhances students' computational thinking and creativity skills while fostering a positive and collaborative learning environment. While the appearance dimension did not exhibit significant differences, the overall impact on students' learning experiences and content creation was evident. The potential of SVVR technology coupled with collaborative project-based learning to revolutionize education is promising, and with further research and refinement, this approach could open up exciting possibilities for transforming how students engage with learning content and collaborate with their peers.

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