

# Enhancing Collaborative Learning through Virtual Escape Rooms: Impact on Participants' Perceptions

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**Abstract**—Digital revolution has transformed education, allowing students to interact, communicate, and collaborate beyond traditional classroom settings. Computer-Supported Collaborative Learning (CSCL) provides opportunities for teamwork and knowledge sharing regardless of geographic location. Recently, Virtual Reality (VR) has emerged as a promising tool to address these challenges, offering immersive, three-dimensional environments that enhance collaborative learning experiences. Collaborative Virtual Environments (CVEs) extend VR's potential by enabling users to interact and work together in shared virtual spaces. Moreover, virtual escape rooms have gained traction as an innovative approach to game-based learning, combining the benefits of collaboration, problem-solving, and engagement to create an immersive and interactive educational experience. In view of the above, this paper explores the innovative use of virtual reality (VR) and educational digital escape room games as tools to promote collaborative learning in synchronous distance education and lifelong learning. By designing a cooperative game-based learning environment, the study seeks to leverage the problem-solving and teamwork skills inherent in such games to enhance the learning experience. The impact of these technologies on participants' perceptions was assessed comparing the information emerged from two surveys conducted before and after the intervention. The findings show that the incorporation of virtual escape room into collaborative learning environments effects positively participants' perceptions.

**Keywords**— *Collaborative learning; Digital escape room; Distance education; Game-based learning; Lifelong learning; Virtual reality*

## I. INTRODUCTION

The rapid development of digital technologies enables students interact, communicate, and collaborate beyond the traditional boundaries of the classroom [1]. Collaborative learning in digital environments, known as Computer-Supported Collaborative Learning (CSCL), has revolutionized education, providing learners with the opportunity to engage in teamwork and knowledge sharing, regardless of geographic location [2,3].

Researches show that CSCL can significantly improve students' academic performance, critical thinking skills, and motivation [4-6]. Moreover, it contributes to the development of communication and metacognitive skills, fostering collaboration and teamwork [3-7]. Additional benefits include

increased self-esteem, reduced anxiety, and improved social relationships [8]. However, despite these advantages, there are studies that highlight the limitations of this technology, such as students' lack of readiness for collaborative learning and technical demands of CSCL environments [9-10].

In recent years, virtual reality (VR) has emerged as a promising tool for enhancing collaborative learning experiences [11]. VR immerses users in interactive, three-dimensional environments, offering new ways to engage with educational content [12]. It allows learners to participate in simulations and problem-solving scenarios that would otherwise be impossible in the physical world [12,13]. In addition to the individual immersive experiences offered by VR, Collaborative Virtual Environments (CVEs) have emerged as a powerful extension of VR's capabilities, enabling multiple users to interact and collaborate in shared virtual spaces, without geographical restrictions [14]. This collaborative dimension of VR further strengthens its role as a useful tool in modern distance education [15,16].

Escape Rooms are increasingly being used as an innovative approach to game-based learning [17]. The benefits of integrating escape rooms into educational settings include enhanced student engagement, increased motivation, and improved learning outcomes [18,19]. Virtual escape rooms, in particular, have gained popularity as an educational tool that encourages collaboration, critical thinking, and teamwork by challenging participants to solve puzzles and complete tasks within a limited time frame [20,21].

In view of the above, this paper introduces a virtual escape room as an innovative tool for enhancing collaborative learning in synchronous distance education and lifelong learning. The game was structured around a series of challenges about art history, that required participants to share knowledge, communicate effectively, and work as a team to find solutions. This virtual escape room was developed to examine the impact of these technologies on participants' perceptions of collaborative learning. The system was evaluated using the SR-CSCL instrument [22] and CLSS measurements [23] before and after the intervention, respectively. The results highlight the positive impact of virtual escape rooms on students' perception of collaborative learning. Such environments enhance the sense of community and active participation, leading to increased engagement and satisfaction. Participants

consider virtual reality as an effective tool for developing collaborative and problem-solving skills. Overall, virtual reality appears to boost their readiness for collaboration and positively influence their collaborative learning experiences.

## II. DESIGNING AND DEVELOPING THE VIRTUAL ESCAPE ROOM

This paper presents a virtual escape room developed for exploring the impact of collaborative virtual environments and digital escape rooms on participants’ perceptions of collaborative learning. The system combines game-based learning, storytelling techniques and distance education principles. As such, it immerses participants in a virtual environment where teamwork and problem-solving are essential to solve the challenges presented and to promote learning. System design focuses on user engagement, communication between the peers and collaborative learning. Moreover, the activities provided by the game were aligned with the learning objectives of the intervention developed.

The intervention designed for utilizing the system is titled "Trapped in Van Gogh’s Art", concerning art history subject. The virtual escape room was designed as a virtual museum with 3 themed rooms, each dedicated to different aspects of the life and art of Vincent van Gogh. Participants start their journey in a central hall that provides an introduction to the artist and sets the stage for the challenges that follow (Fig. 1). The virtual environment provides an immersive learning experience that not only promotes collaboration among participants but also develops their critical thinking skills by exploring art-related content.



Fig. 1. Screenshot of the virtual escape game: Panoramic view of museum’s rooms

One of the main goals of system design was to create a sense of community and social presence among participants. Thus, collaborative tasks and real-time communication tools were incorporated into the virtual escape room, encouraging students to interact with other peers and with the learning material. These activities were based on real-world problem-solving scenarios and intended to develop 21st-century skills, such as critical thinking, communication, and teamwork. During the intervention, a coordinator monitored participants' engagement and interactions, offering guidance when necessary (Fig. 2).

The system was developed using Spatial.io, a platform that supports immersive virtual environments. This platform enabled the creation of a realistic and interactive space where participants could collaborate and interact in real-time.



Fig. 2. Screenshot of the virtual escape room during participants’ collaboration to solve a challenge

## III. RESEARCH METHODOLOGY

This study aims to explore the potential of virtual reality and digital escape rooms as a pedagogical tool that promotes collaboration, critical thinking, and student engagement in modern distance learning environments. For this purpose, the quantitative research method was employed, distributing two questionnaires to participants: one before the intervention and another after the intervention.

The questionnaire used before the intervention was based on SR-CSCL (Self-Readiness for Computer-Supported Collaborative Learning) instrument, introduced by [22], measuring the perceived level of student readiness for involving in online collaborative learning environments (Table I). It consists of three dimensions: a) learners’ perceptions of collaborative learning, evaluating students’ adaptability to online collaborative environments and virtual games, b) motivation for collaborative learning, focusing on student readiness to engage in teamwork, and c) development of collaborative skills, exploring learners’ expectations of their ability to engage in collaborative learning.

After the intervention, a questionnaire based on collaborative learning, social presence and satisfaction (CLSS) measurements introduced by [23], was used for assessing participants' perceptions regarding their collaborative learning experience in the virtual escape room environment (Table II). This survey includes dimensions such as the sense of community, social presence, satisfaction, and the perceived effectiveness of collaborative learning activities.

Both questionnaires use a 5-point Likert scale for their responses, ranging from "Strongly Disagree" to "Strongly Agree", and were distributed online.

TABLE I. SR-CSCL BASED QUESTIONNAIRE.

Dimension	Statement
Perception of virtual collaborative learning	I am good at using the internet to communicate effectively with others.
	I am willing to use online collaboration tools to complete group work.

	I feel comfortable interacting with other users in virtual game worlds.
	I feel ready to explore virtual game worlds.
	I feel confident in my ability to collaborate with others in a virtual world environment.
Motivation for collaborative learning	I find it fun/interesting.
	I believe it will help with my academic/personal development.
	I believe I can work effectively with other participants.
	I hope to develop a good relationship with the other participants.
Collaborative Skills	I will listen to all other group members' ideas.
	I will be able to apply an appropriate conflict resolution strategy.
	I will participate wherever needed.

TABLE II. CLSS-BASED QUESTIONNAIRE.

#	Question Item
Q1	The collaborative learning experience in this environment is better than in a face-to-face learning environment.
Q2	I felt part of a learning community in my group.
Q3	I actively exchanged my ideas with members of the group.
Q4	I managed to develop new skills and knowledge with the help of other group members.
Q5	I was able to develop problem-solving skills through collaboration.
Q6	Collaborative learning in my group was effective.
Q7	Collaborative learning in my group was time-consuming.
Q8	Overall, I am satisfied with my collaborative learning experience in this educational activity."

The sample consisted of 30 adults who responded positively to an open invitation send to the university community by the authors, for participating in the developed distance and lifelong learning intervention. The participants included 14 males and 16 females, evenly distributed across three age groups: 18-24, 25-29, and 30-34, with 10 individuals in each group. All participants expressed an interest in the arts and indicated prior experience in distance and lifelong learning programs.

#### IV. EVALUATION RESULTS AND DISCUSSION

In order to evaluate participants' perceptions regarding the incorporation of virtual escape rooms into collaborative learning settings, the SR-CSCL instrument [22] and the CLSS measurements [23] were used. The first one aims to measure participants' perceptions and attitudes regarding their readiness for computer-supported collaborative learning, while the second one evaluates their experience and perception on collaborative learning in a virtual reality environment, with an emphasis on dimensions such as sense of community, social

presence, satisfaction, and perceived effectiveness. The comparative analysis of the two instruments involves examining the responses collected before and after the instructional intervention.

##### A. Perceived Collaborative Learning Experience

Perceived collaborative learning experience refers to learners' perceptions of how effective, engaging, and beneficial the collaborative process is for their learning. Based on CLSS questionnaire, the perceived collaborative learning experience was evaluated through 8 questions, as shown in Fig. 3.

The majority of participants answered positively, as indicated by higher median and mean scores across most categories, particularly regarding teamwork, knowledge exchange, and the sense of belonging within the group. However, time efficiency took lower scores indicating that participants found the process time-consuming. Overall, the results show that collaborative virtual escape rooms had a positive effect, enhancing engagement and collaboration, while also identifying potential areas for improvement, particularly regarding time management.

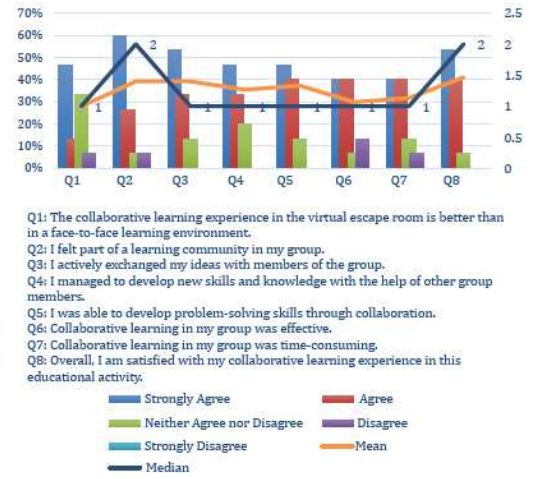


Fig. 3. Evaluation of perceived collaborative learning experience

Fig. 4 illustrates the comparison of prior confidence in collaborating and the final attitude towards collaborative learning experience using virtual escape rooms. One of the key findings is that after the intervention 47% of participants strongly agreed (and 13% agreed) that the collaborative learning experience in the virtual environment was superior to face-to-face learning. This indicates that virtual reality can offer a collaborative platform that overcome physical limitations, fostering engagement and connection among participants.

However, prior to the intervention, according to the SR-CSCL scale which assesses participants' readiness to collaborate in a virtual world, 33% of the participants held a positive perception of their collaborative abilities in virtual environments. Furthermore, 40% remained neutral, indicating a level of uncertainty or hesitation. This discrepancy highlights the importance of understanding personal readiness when

designing effective computer-supported collaborative learning environments.

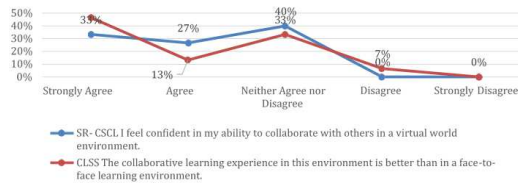


Fig. 4. Prior readiness on collaborating in virtual environments and final attitude towards collaborative learning experience using virtual escape rooms.

### B. Sense of Community and Social Presence

Regarding the sense of belonging to a learning community, a significant 87% of participants (60% "strongly agree" and 27% "agree") expressed feeling integrated and connected within their learning groups. This highlights the positive role of the virtual collaborative environment in creating communities that promote engagement and shared learning experiences, overcoming physical distance between participants. This sense of belonging is crucial for promoting effective collaborative learning, enabling participants to connect and interact efficiently.

Moreover, when comparing the SR-CSCL question: "I hope to develop a good relationship with other participants", with the CLSS question: "I felt part of a learning community in my group", as shown in Fig. 5, participants' perceptions of community engagement improved significantly after the intervention. While initially, 27% of participants expressed this hope, after the intervention, 60% "strongly agreed" that they felt they belonged to a learning community. This demonstrates the intervention's effectiveness in strengthening participants' sense of community within the virtual collaborative environment.

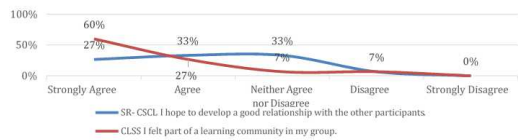


Fig. 5. Evaluating sense of Community and Social Presence

Regarding student engagement in virtual collaborative environment, the findings shows a clear improvement in participants' perceptions of idea exchange and collaborative behaviours after the intervention (Fig. 6). Before the intervention, while most participants expected to engage in idea exchange, a significant portion (28%) remained neutral. After the intervention, a much higher percentage (53%) strongly agreed that they actively exchanged ideas, and the neutral group was reduced to 13%. This indicates that the virtual environment effectively encouraged more active participation and collaboration, leading to a stronger sense of engagement. It seems that virtual escape rooms succeeded in enhancing collaborative attitudes, as the majority of participants felt more involved in the exchange of ideas after the intervention.

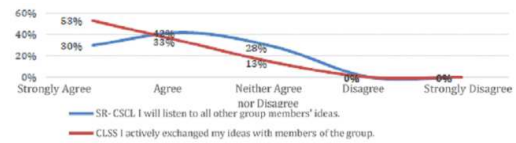


Fig. 6. Comparative analysis of active participation before and after the intervention

### C. Skills Development

Comparing participants' responses regarding the development of collaborative and problem-solving skills (Fig. 7), the findings show that before the intervention (SR-CSCL), 77% of the participants (40% strongly agree and 33% agree) believed that they could develop such skills using the virtual escape room. Whereas, after the intervention (CLSS), there was a notable increase in the percentages, namely 87% of the participants (47% strongly agree and 40% agree) stated that they were able to develop problem-solving skills through collaboration. This result suggests that the integration of virtual reality not only supports collaborative learning but also contributes to the development of individual skills through peer interaction.

Virtual escape rooms appear to have slightly enhanced participants' perceptions of their collaborative and problem-solving skills. The lack of negative responses further supports the effectiveness of virtual collaborative learning environments on skills development.

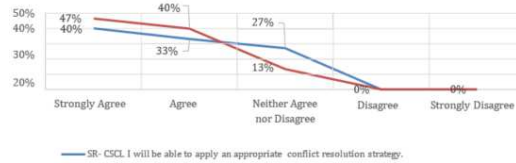


Fig. 7. Evaluating the Development of Collaborative and Problem-solving Skills

### D. Self-efficacy

Self-efficacy is the belief in one's ability to successfully execute tasks and overcome challenges. In order to evaluate the self-efficacy before and after the intervention, the SR-CSCL item "I am willing to use online collaboration tools to complete group work." was compared with the CLSS question "Collaborative learning in my group was effective", respectively (Fig. 8). The comparison shows a positive shift in participants' self-efficacy after the virtual reality experience.

In particular, self-efficacy in virtual collaboration was initially 33% "strongly agree" and 27% "agree". After the intervention, these percentages increased to a total of 80% (40% "strongly agree" and 40% "agree"), indicating that the intervention not only enhanced participants' confidence in virtual collaboration but also positively influenced their evaluation of the effectiveness of collaborative learning in the virtual environment.



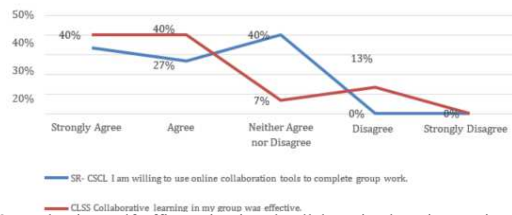


Fig. 8. Evaluating Self-efficacy in virtual collaborative learning environments

### E. Discussion

The findings highlight the positive impact virtual escape rooms had on participants' perceptions. The majority of participants stated that collaborating in the virtual environment was both effective and engaging, especially in terms of teamwork, knowledge sharing, and feeling a sense of belonging within their group. However, time efficiency emerged as an area of concern, as many participants found the process time-consuming.

Another significant outcome is the positive shift in participants' attitudes toward virtual collaborative learning. Before the intervention, participants expressed uncertainty regarding their ability to collaborate in virtual environments. After the intervention, most participants believed that virtual escape rooms were even more effective than face-to-face learning, emphasizing the potential of virtual reality to overcome physical constraints and promote better engagement among learners. This highlights the importance of considering individual readiness in virtual collaboration when designing learning environments.

Finally, the findings indicate a clear improvement in participants' self-efficacy in virtual collaboration. Before the intervention, many participants were unsure about their collaborative skills in virtual environments. Afterward, participants reported that they collaborated effectively with the peers in their group. This improvement in self-efficacy in conjunction with the development of problem-solving skills through peer interaction, underscores the value of virtual escape rooms as a tool for enhancing both individual skills and group collaboration.

### V. CONCLUSIONS

Integrating collaborative virtual environments with digital escape rooms creates an innovative game-based learning approach that fosters teamwork, enhances interaction, and promotes problem-solving skills. To this direction, this paper presents a virtual escape room where participants collaborate in real-time to solve game challenges. The aim of this study is to evaluate the impact of these technologies on participants' perception of collaborative learning.

The findings show that integrating virtual reality into learning process significantly enhances participants' perceptions of collaborative learning. A substantial portion of participants found virtual escape rooms to be superior to traditional methods, increasing their confidence in the collaborative abilities within virtual environments. They

reported a strong sense of belonging and active exchange of ideas within virtual communities, highlighting the role of virtual reality in promoting social presence and collaboration. Participants recognized the effectiveness of virtual escape rooms in developing skills and critical thinking, despite potential time-consuming aspects. Overall, virtual escape rooms seem to foster engagement, cooperation, skills development, and satisfaction within virtual communities.

Part of our future plans is to evaluate the developed system using a larger sample and a longer experimental period, as well as to apply further evaluation frameworks in order to ensure its effectiveness. Moreover, we intend to extend the system including different educational contexts and subjects, in order to investigate the impact of virtual escape rooms on diverse educational settings.

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