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Immersive Virtual Learning Experiences of Senior Secondary School Students from India and Russia: A Mixed Method Study

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ABSTRACT

Virtual Reality (VR) provides an immersive learning (IL) experience by simulating real-world scenarios that bridge the gap between theory and application. VR simulations are interactive and enhance student engagement across a range of concepts, from simple to complex. India and Russia share similar cultural and historical backgrounds, and both are committed to creating a multipolar world. Both are large developing countries with several strategic partnerships and international cooperation. Hence, this study aims to capture the learning experiences of internationally paired students in an IL environment and their attitudes towards IL environments, to mutually contribute to teaching and learn in these countries. Students experienced immersive learning through stand-alone head-mounted virtual reality cameras with a controller. The study employed a mixed-methods research design involving a quantitative and qualitative explanatory approach. Researchers paired 100 senior secondary school students from Russia (n = 50) and India (n = 50) and exposed them to virtual IL experiences. Researchers used the user-experience IL environment scale, the VR-IL environment attitude scale, and an interview guide to collect the data of the study. Quantitative data were analyzed using descriptive statistics, a correlation test, and regression. Qualitative data were analyzed through narrative thematic analysis. Researchers triangulated the IL experiences measured through quantitative and qualitative methods. The study found a positive correlation between IL experiences and attitude towards the IL environment. Further, IL experiences accounted for 43.5% of positive attitudes towards the IL environment. The qualitative analysis revealed both positive and negative aspects of VR-IL environment experiences. The study's findings add value to the cognitive-affective theory of learning with media, as it includes knowledge construction, emotional connection, and motivation for learning. Future studies may explore the benefits of the IL environment with artificial intelligence (AI) and generative AI towards teaching and learning.

Keywords: Metaverse, virtual reality, virtual learning, immersive learning, mixed reality

In today's society, technology plays a vital role, radically transforming the way we approach teaching and learning for our students (Lorenzo et al., 2022; Radianti et al., 2020; Wu et al., 2021). A glance at recent educational technologies includes online learning, mobile learning, blended learning, gamification, learning applications, robotics, and immersive learning (IL; Aristek Systems, 2022). Immersive virtual reality is an increasingly popular approach to support learning in current education environments (Wu et al., 2020). Recent technological developments are using virtual reality (VR) in various areas of education and training in the educational setting (Dengel et al. 2019). Digital learning advancements, such as IL through VR, may promote not only technological literacy but also innovative thinking, interaction, engagement, and problem-solving capacity (Beck et al., 2020). Therefore, the paradigm shift in education involves incorporating innovative, tech-integrated pedagogical approaches that leverage e-resources, gamification, and IL technologies. Unfortunately, the teaching methods in schools have remained essentially unchanged, with little innovation, especially in low-income countries like India (Bhattacharjee et al., 2018). Simultaneously, the information and communication technology (ICT) fields have expanded rapidly over the past decade, offering application software, digital devices, and an efficient learning management system to the field of education. Consequently, teachers around the world are struggling to keep up with such rapid developments. Although technological developments offer new opportunities to engage learners, there is a knowledge gap about what, when, and how to use them for teaching and learning. Although anyone can access VR, there is little evidence of collaborative projects involving students from different countries.

Furthermore, the researchers found little or no empirical research using a mixed-methods approach to explore the effects of an IL environment intervention on learning. This is especially true for the lower and middle-income countries, including India, where technology use remains underutilized across the public education sector. A lack of funding, austerity measures, and inadequate professional training are among the reasons for these circumstances. Yet, lecture-based and rote methods of teaching and learning dominate Indian classrooms. However, recent studies emphasize the use of a technology-integrated learner-centered approach in teaching (Scholtz et al. 2019). Although computer-assisted teaching was prevalent, VR, augmented reality (AR), mixed reality (MR), and the application of artificial intelligence (AI) warrant further exploration in the context of teaching and learning.

VR is the immersion effect in an interactive virtual environment created by 3D graphics and other computer interfaces (Pan et al., 2006). AR is a technology-enabled system in which computer-generated content is added to the real world in real time (Milgram & Kishino, 1994). MR is a technology-enabled system in which computer-generated content is merged with the real world in real time and interacts with it (Park et al., 2020). Immersive learning (IL) is a method of learning in which learners are immersed in learning either through a technology-supported virtual learning environment or any other learning material (Zhi & Wu, 2023). A VR learning environment is a learning experience that enables a learner to watch a 360° (3D) VR video in an interactive environment on a VR camera device. Here, the learner is immersed in a realistic computer-generated artificial world to learn (Burdea, 1999). The Metaverse is a place that combines high-fidelity communication with an innovative way to tell stories, borrowing from the entertainment and mobile gaming industries (Jeon, 2021). Gamification is a learner-centered pedagogical approach that integrates game-based elements and mechanics to make learning more engaging, motivating, joyful, and dynamic (Pozo-Sanchez et al., 2022). A review of the literature warrants more empirical studies to confirm the effects of these new trends, especially across different classroom setups such as collaborative, active learning, and flipped classroom approaches. An IL environment is a learner experience in which learning in a simulated environment includes real-world scenarios and contexts, using technologies such as AR, VR, and MR (Mystakidis & Lympouridis, 2023).

Virtual Immersive Learning Environment

The virtual learning environment (VLE) is a three-dimensional extension of VR that allows users or learners to interact and share a virtual space where learning occurs. The VLE is said to provide learners with a highly effective artificial experiential learning environment (Beck, 2019; Bhattacharjee et al., 2018). VR, AR, and MR are enhancing learning experiences for higher education learners through digital tools (Gaspar et al., 2020). Immersive digital reality experiences actively engage learners in a digital realm through their sensory experiences. Virtual reality has the potential to improve learning outcomes by presenting concepts in a three-dimensional space and providing IL experiences (Fabris et al., 2019). VR tools offer advanced methods of human-computer interaction (Papanastasiou et al., 2019) and facilitate experiential learning driven by spatial cues. IEL promotes a range of learner skills, including collaboration, cooperation, self-reflection, and spatial abilities. It further supports game-based and student-centric learning through a multisensory experience (Papanastasiou et al., 2019). The development of an immersive learning tool is digital, intuitive, collaborative, and prototypic in nature (Weyhe et al., 2018). In medical education, without prior understanding of VR, the "immersive-anatomy atlas" actively and intuitively assisted in performing specific activities, thereby enhancing understanding. Immersive learning appears to improve performance across various knowledge domains (Beck, 2019; Liu et al., 2020). Additionally, IL provides a highly interactive virtual setting that closely matches the real world, thereby enhancing learner engagement (Beck, 2019).

Virtual Reality Experience

In the VR environment, an enhanced immersive effect can be achieved by reflecting natural body motions into the experience. Immersive VR is most experienced with VR headsets; the display is contained inside a device worn by the viewer (De Back et al., 2021). A review of the literature shows that, to date, most research has used VR as a training interface or skill application, a tool to clarify concepts or knowledge, or a communication facilitator (Liu et al., 2020). VR and AR overlay virtual objects onto the real world, offering interesting and widespread opportunities to study various components of human behavior and cognitive processes (Dünser et al., 2006). VR can provide "here-and-now" experiences to test theories and offer instant feedback to refine them. Immersive environments can support experiential learning, solidifying ideas and making real what is otherwise unthinkable and unimaginable (Fabris et al., 2019; Yilmaz et al., 2015). In fact, VR has revolutionized how people of all ages learn and work. VR environments provide users with the opportunity for deeper interaction, leading to the creation of communities, decreased social anxiety, enhanced motivation, and increased engagement (Yilmaz et al., 2015). Further, VR may facilitate the development of higher-order thinking and problem-solving abilities (Yilmaz et al., 2015). The review of previous findings indicates that VR IL environments, viewed through the constructivist lens, may be a more instinctive and practical approach to gain information beyond the academic curriculum (Beck, 2019; Liu et al., 2022; Makransky et al., 2021; Pirker et al., 2020; Winkelmann et al., 2020). For example, Chu et al. (2019) found that an immersive, interactive, real-time, real-scale spatial relativity simulation in virtual reality provides a high level of immersion and enjoyment and yields a significant positive learning outcome.

Purpose of the study

While several researchers have explored VR learning environments in the past two decades, their research was primarily conducted in high-income countries and developed countries with sufficient financial resources, with only a few in countries with emerging economies. However, there is a dearth of research on VR and IL environments in low and middle-income countries. In a recent study, a teacher reported a few challenges while exploring virtual learning environment, such as a lack of teachers' competency in using VLE, lack of class preparation competency among teachers, lack of expertise on trouble shooting technical glitches, lack of technological and pedagogical content (TPACK) knowledge, and resistance to change or adapting to the newer ways of tech-integrated teaching (Serrano-Ausejo & Mårell-Olsson, 2024). A recent study reported challenges among international students learning in VR-IL environments, namely cultural adaptation, communication barriers, variations in hardware and software components, access to technology, and academic engagement styles (Lodis Inggridvara Ivada et al., 2024). Further, there are issues in language, student learning competency, education systems, and instructor knowledge (Yassin et al., 2020). A study conducted by Luaran et al. (2025) revealed additional challenges in IL environments, including high costs of setting up IL environments, creating content compatible with immersive learning, and developing detailed technical support materials. Similarly, Ahmadi and Gilardi (2024) reported affordability and content creation as the main challenges of IL environments. Another study on the IVR application in online learning identified issues with hardware, software, internet bandwidth, organization, and methodology (Abadia et al., 2024).

At the same time, some studies reported the merits of VR-IL environments. A study by Chen (2024) reported the benefits of immersive learning in cross-cultural contexts, including increased cognitive adaptability, enhanced cross-cultural cooperation, and improved cross-cultural sensitivity. A recent study revealed that immersive virtual reality simulation can bridge the cultural competence-related issues in education (Chae et al., 2023). A study conducted by Torres and Statti (2022) on learning through IL environments across borders found benefits in developing international-mindedness, motivating students, and achieving cognitive gains. Similarly, Knutzen (2025) found that VR-ILR develops intercultural communication competence in a study on intercultural communication via social VR rooms.

A systematic review by Liu et al. (2025) on IL environments emphasized the need to understand the VR context, the variety of implementation models, and students' behavioral patterns when using IL environments. Nevertheless, innovation in education these days emphasizes international collaboration, even at the school level. Therefore, it is worth exploring students' understanding of IL experiences in cross-cultural contexts, as well as the challenges they face when learning alongside students from other nationalities. Thus, the researchers planned this unique study to understand the nuances of VR immersive learning in a large and densely populated country like India and selected the Russian Federation as a cooperative sample to explore the benefits and challenges of VR learning.

The present study is unique in that it facilitated the collaboration of higher-level secondary students in India and Russia in an IL environment. Specifically, it explored learners' attitudes towards VLEs and their personal experiences with immersive virtual learning environments within an internationally paired student group. Furthermore, the study draws insights into how VR can bridge cultural and geographical gaps in learning.

Objectives of the Study

1. To measure the learning experiences and attitudes towards IL environments of internationally paired senior secondary school students.
2. To determine whether there is any relationship between IL environments and learners' attitude towards an IL environment.
3. To determine whether IL experiences predict learners' attitudes towards IL environments.
4. To explore the benefits, drawbacks, and ways to improve students' IL experiences.

Theoretical Frameworks

The technology acceptance theory (TAT) guided the present research (Davis, 1987). TAT is an information processing system that explains how the user agrees to a technology and can use it. The successful introduction of any new technology largely depends on end users' ability and behavioral intention. Immersive learning through a head-mounted virtual camera provides internationally paired senior secondary school students with a technology-integrated learning experience. Several factors affect the IL experience, including learners' perceived ease of use of the IL environment platform and their perceived usefulness of the overall setup for effective learning of concepts (Silva, 2015). Vygotsky's cognitive constructivist learning theory explains how the IL environment scaffolds learners' knowledge construction. The zone of proximal development (ZPD) theory informs the present study, which aims to identify learning differences between IL environments and non-IL environment conditions during the learning process (Vygotsky & Cole, 1978).

Context of the Study

VLEs have increased dramatically in the last decade, especially during the pandemic and post-pandemic periods. Although teachers' technological, pedagogical, and content knowledge has increased, its implementation remains slow. Studies show that integrating technology into teaching has enhanced learning, learners' curiosity, interest, academic performance, and attitudes towards learning (Papanastasiou et al., 2019). Therefore, adopting newer technologies as a pedagogical practice is becoming increasingly important, especially for the younger generation, many of whom have been frequently exposed to them. However, this is primarily true for students in developed countries, who are reaping the benefits of technology-integrated learning, whereas students in low-income countries lag behind. Thus, the digital gap is widening internationally between wealthy and less well-off countries. Moreover, senior secondary school is an essential stage in a student's life, as it marks the decision point for their future academic journey (Prakasha & Kenneth, 2022). International exposure and international collaboration in K-12 education are gaining popularity. Students from developing and low-income countries aspire to pursue higher education in developed countries or top universities worldwide. Thus, providing them with the best learning environment is significant for all academic stakeholders. This specific collaboration model fosters confidence and exposure through engagement with an international peer group. Therefore, the present study aims to provide an opportunity for global collaboration, at least on a virtual platform. It aims to understand the learning experiences of senior secondary school students when paired with international students in an online IL environment.

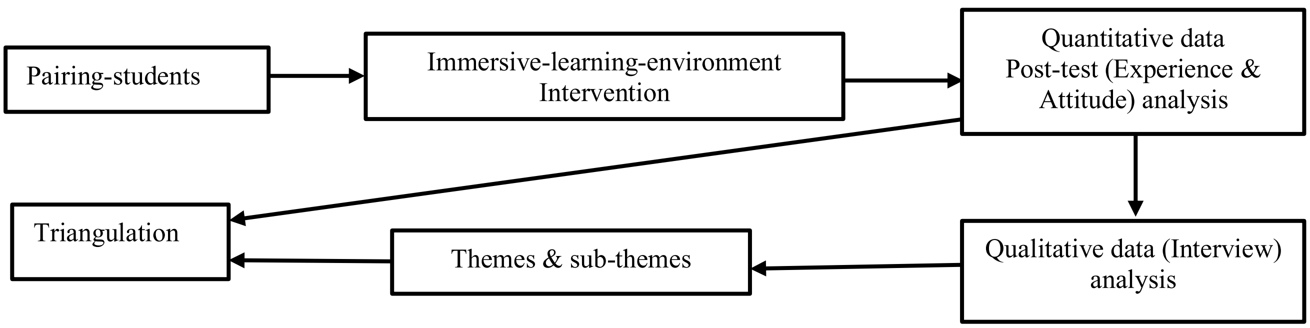
METHODS

The present study employed an explanatory sequential mixed-method design (Edmonds & Kennedy, 2017), which first included quantitative measurements, including (a) user experiences of IL environments and (b) the attitude towards IL experiences–both of which were collected with survey questionnaires on a Google form. Two standardized instruments were used to measure IL experiences and attitudes towards IL among 100 internationally paired senior secondary school students from Russia ($n = 50$) and India ($n = 50$). The first instrument was the User Experience in Immersive Virtual Environments Scale (Tcha-Tokey et al., 2016), which had 75 items for participants to respond to on a 10-point Likert scale (*strongly disagree* to *strongly agree*). The second instrument was the attitude towards virtual reality learning environment (Huang et al., 2010), which comprised 25 items, each measured on a 7-point Likert scale (*strongly disagree* to *strongly agree*).

Based on the initial quantitative analysis results and to deepen their understanding of the quantitative findings, researchers incorporated qualitative methods. Researchers developed the interview items based on the quantitative results, aligning with a quantitative-qualitative sequential explanatory research design. Researchers used descriptive statistical results, including response percentages across various items, to develop the interview items. Although most interview items focused on positive aspects, negative aspects, and improvements in IL experiences, researchers also prompted participants with follow-up sub-questions to elicit in-depth responses. The data collected from the semi-structured interviews were transcribed for narrative thematic analysis (Ahmed et al., 2025; Braun & Clarke, 2006). Eventually, researchers interpreted the quantitative and qualitative results through triangulation. The triangulation procedures helped analyze the points of convergence and divergence between quantitative and qualitative results (Flick, 2018). Figure 1 below presents the design flowchart of the present study.

Figure 1

Flow Chart of the Study Design



Study Sample

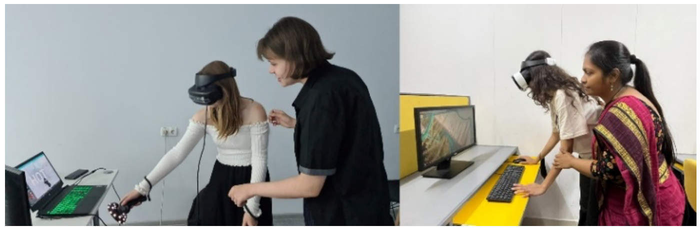
The study samples were from India and the Russian Federation. They were selected as a precursor to develop a memorandum of understanding to strengthen international cooperation between the universities of these countries. Furthermore, their cultural and linguistic backgrounds are similar, and both countries support a multipolar world order. The study employed a purposive sampling technique to select students who expressed a willingness to participate and were conversant in English. Researchers recruited 50 grade 12 students from India and 50 grade 11 students from Russia. Their ages ranged from 17 to 18 years. In India, grade 12 is the final stage in public education, after which students may pursue higher education studies if they choose to do so. In Russia, grade 11 is the last in public education, after which students move on to higher education if they choose to do so. These grade levels were selected to match the level of content knowledge and to establish equivalency by age and readiness for higher education. As participants were internationally paired, their equivalency was established based on grade level, age level, and the subject content under consideration. Both groups had a lecturer with experience in using IL technology to guide their respective cohorts. The collaborating institutes ensured the availability of necessary infrastructure, including stand-alone head-mounted VR cameras, controllers, and other essential accessories.

Immersive Learning Environment Intervention

The cooperating institutes provided the head-mounted stand-alone VR cameras, navigation controllers, 360° 3D VR videos, and other necessary accessories to the study participants in their respective educational technology labs. The lecturer gave an orientation demonstration to the students on using the stand-alone VR camera and controller, as well as other expected tasks. Figure 2 presents a picture of laboratory experiences with a VR setup. In the figure, the computer mirrors the student's view in the stand-alone VR headset, allowing other students to see and understand how the student is exploring the 3D 360° VR video content during the tutor's initial demonstration. Connecting to a computer provides the VR headset with battery backup, ensuring safety. The study did not utilize a mobile-based VR headset, as it is not practical in a school setting. The labs utilized Meta Quest or Oculus Quest stand-alone VR headsets, with all lab computers equipped with seamless video streaming software or an app to support 360° 3D VR video playback throughout the experiment.

Figure 2

The Immersive Learning Experiences of Internationally Paired Students



The lecturers coordinated the lab activities, which lasted almost a month, and consisted of various assignments that the students had to complete. The cooperating lecturers analyzed the subject contents of grade 12 (India) and grade 11 (Russia) and selected 15 common topics about general environmental sciences (deep-sea, climate change, etc.) across various subjects. Lecturers then mapped 50 readily available VR resources (e.g., YouTube, RT 360 VR app videos, and New York Times VR app videos) on the internet to the selected topics. Next, lecturers provided links or downloaded files for these 360° 3D VR videos to each pair, so that two students—one from India and one from Russia—watched the same content. Students discussed their experiences and solved worksheets on the topic they watched through a VR headset with their partner student, who was connected via an online video conferencing platform for discussion. Each pair had to engage with all 15 topics, and each lab session lasted 1 hour, including watching a video, peer discussion, and solving worksheets. The times were 12 to 1 PM in Russia and 3:30 to 4:30 PM in India, as Russia is 2 hours and 30 minutes ahead of India. The lab schedule was conducted every other day. It took almost a month to complete the intervention, including Sundays and other general holidays. The researchers administered the standardized instruments to measure the IL experiences and attitudes towards IL after the intervention. The study followed a quasi-experimental single-group post-test-only design. Researchers selected a single-group post-test-only design because participants lacked the necessary knowledge and attitudes regarding the IL environment prior to the intervention. Researchers stored the data safely in an encrypted file accessible only to them. They then imported the data to SPSS version 24 for statistical analysis.

Qualitative Interviews

The interview sample included 10 students (five pairs; each pair consisted of one Indian and one Russian student). Researchers selected the five pairs based on their performance on the IL experience survey. One pair each from the lower and upper quartiles of the distribution and three pairs from the inter-quartile range. Researchers conducted interviews with the selected five pairs of students to gain an in-depth understanding of their immersive learning environment experiences. Table 1 presents the demographic details of the participants and interview questions. Interviews were conducted online via the Webex video conferencing tool. Researchers followed all interview protocols and recorded the interviews with participants' consent. The recorded interviews were transcribed, and the transcripts were stored safely in a password-protected file accessible only to the researchers.

The interviews were analyzed using narrative thematic analysis, with manual coding. The steps used in the analysis were,

- reading the interview transcripts multiple times to understand the narratives and be familiar with the data thoroughly
- taking notes of the initial patterns and significant points
- identifying key themes, repeated ideas, and any typical points
- grouping the similar ideas into categories
- coding the data or narratives into main themes
- analyzing the main themes to see relationships, combining, splitting, mapping connections, and developing into subordinate themes
- interpreting the themes and subthemes along with quotations.

Researchers presented the emergent themes and sub-themes in Table 4 of the results section.

Validity and Reliability of the Instruments

The study used multiple tools: the user experience scale, the attitude towards VRLE scale, and the interview guide. However, the VR intervention included video resources and worksheets. All the tools were thoroughly examined by a panel of experts for face and content validity; the experts' suggestions were incorporated into the final versions of the tools. To assess the reliability of the user experience scale and attitude scale, the researcher employed Cronbach's alpha internal consistency test in SPSS version 24 and found reliability coefficients of 0.86 and 0.81, respectively. Thus, the tools used were found highly reliable (Nunnally, 1978). The major interview items were also presented to the panel of experts for their relevance, face, and content validation.

Ethical considerations

The study obtained Institutional Review Board approval to conduct this collaborative project. Further obtained consents from all participating lecturers who helped at the VR lab. The study obtained signed assent forms from all participants, both during survey-level data collection and during semi-structured interviews. Researchers gave interview participants the option to withdraw from the study at any time if they did not feel comfortable.

Table 1

Participant Demographics

Pair no.	Pseudonym	Gender	Age	Class	Country
1	P 1	Male	18	Senior secondary school	Russia
	P 2	Female	17	Senior secondary school	India
2	P 3	Male	18	Senior secondary school	Russia
	P 4	Male	17	Senior secondary school	India
3	P 5	Female	17	Senior secondary school	Russia
	P 6	Female	18	Senior secondary school	India
4	P 7	Female	17	Senior secondary school	Russia
	P 8	Male	18	Senior secondary school	India
5	P 9	Male	18	Senior secondary school	Russia
	P 10	Female	18	Senior secondary school	India

Semi-structured interview questions

- In your opinion, what were the positive points about your VRIL experience? Elaborate
- In your opinion, what were the negative points about your VRIL experience? Elaborate
- Do you have suggestions to improve this virtual reality IL environment? Explain

RESULTS

Researchers have presented the results of the present study in two parts. Part one presented the results of quantitative analysis, and part two presented the results of qualitative analysis. Following these results, researchers discussed data triangulation in the mixed-method design, and recent studies support their discussion.

Part 1: Quantitative Analysis

Study Objective 1: *To measure the learning experiences and attitudes towards immersive learning environments of internationally paired senior secondary school students.*

To address Study Objective 1, researchers employed descriptive statistics, and the results of which are presented in Table 2 below.

Table 2

Study Descriptive Statistics

	N	Minimum	Maximum	*M*	Std. Deviation	Q1	Q2	Q3
IL Experience	100	160	700	477.40	127.910	385	470	580
Attitude towards IL Environment	100	32	112	78.18	18.513	68	80	92

As shown in Table 2, students had a high level of IL experiences, with an average score of 68% of the total score (M = 477.40, maximum score = 700). Nevertheless, students had an average score of 69.8% on the measurement of attitude towards IL environments (M = 78.18, Maximum score = 112). Overall, participants had positive IL experiences and a positive attitude towards the IL environment. This implies users' acceptance of VR technology, and a positive attitude indicates their readiness to use it, as per Davis's (1987) technology acceptance theory.

Study Objective 2: *To determine whether there is any relationship between IL experiences and learners' attitudes towards the IL environment.*

To address Study Objective 2, the study employed the Pearson correlation test and found a correlation coefficient of 0.664 ($r = 0.664$). The results are presented in Table 3 below. There is a strong positive correlation between IL experiences and attitudes towards the IL environment among internationally paired senior secondary school students. As the correlation was positive in the sample, the attitude towards VR technology developed by individuals results from their interactions with their partners and the immersive environment, as per Vygotsky's theory.

Table 3

Pearson Correlation Test Results

Correlations		IL Experience	Attitude towards IL Environment
IL Experience	Pearson Correlation	1	.664**
	Sig. (2-tailed)		.000
	N	100	100
Attitude towards IL Environment	Pearson Correlation	.664**	1
	Sig. (2-tailed)	.000	
	N	100	100

Note. **Correlation is significant at the 0.01 level (2-tailed).

Study Objective 3: *To determine whether learners' attitude towards the IL environment is predicted by IL experiences.*

To address Study Objective 3, the study employed a simple linear regression test. The results of the regression analysis are presented in Tables 4 and 5 below, along with the scatter plot in Figure 3.

Table 4

Regression Results Between IL Experience and Attitude Towards IL Environments

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
1	.664[a]	.441	.435	13.911

Note. [a]Predictors: (Constant) IL Experience; Dependent Variable: Attitude towards IL environments.

Table 5

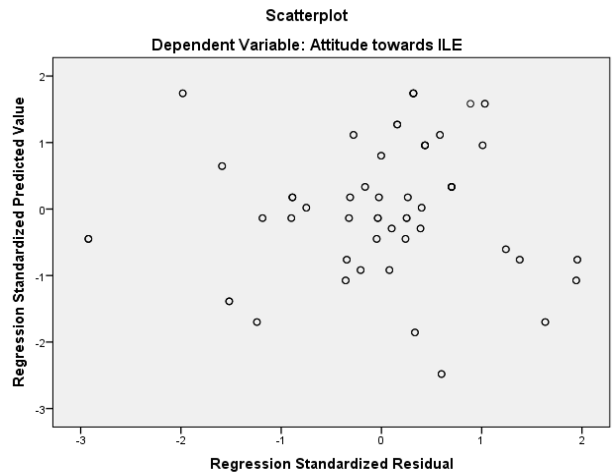
Regression Model Fit

Model	Sum of Squares	*df*	Mean Square	*F*	Sig.
Regression	14964.512	1	14964.512	77.331	.000[a]
Residual	18964.248	98	193.513		
Total	33928.760	99			

Note. [a]Predictors: (Constant), IL Experience; Dependent Variable: Attitude towards IL environments.

Figure 3

Scatterplot of the Regression Analysis



From Table 4, the regression statistics indicate that 44.1% (R^2) of the variation in attitude towards the IL environment is explained by the IL experiences of the study participants. The adjusted R^2 value of 43.5% ($< R^2$) indicated that additional predictors will not add any value to the model. From Table 5 ($F = 77.331$, $p = 0.000$), we see that the *p*-value is less than 0.05, indicating that the variance is significant and the model is a good fit. Figure 3 presents the scatterplot of residuals against predicted values. Thus, providing a user-friendly IL platform and interactive content design fosters a positive attitude towards learning in an immersive environment.

Part 2: Qualitative Analysis

Study Objective 4: *To explore the benefits, drawbacks, and ways to improve students' IL experiences.*

To address Study Objective 4, the study employed narrative thematic analysis through manual coding of the qualitative data. The results of the thematic analysis are presented in three sections: Section I discusses the benefits of IL environments; Section II discusses the drawbacks of using VR-IL environments; and Section III discusses ways to improve IL experiences for teaching and learning. Table 6 below presents the main themes and sub-themes that emerged from the narrative thematic analysis for each interview section.

Table 6

Themes and Sub-themes that Emerged from the Thematic Analysis

Immersive learning experience	Main themes	Sub-themes
I. Benefits	1. Inspirational and unique	1.1. Unparalleled interaction 1.2. Realistic experience and beyond imagination 1.3. Motivates to learn
II. Drawbacks	2. Addiction and health	2.1. Sensory strain 2.2. Addiction 2.3. Curtail social life
III. Ways to improve the experience	3. Collaborative features	3.1. Collaboration 3.2. Content aligned with curriculum 3.3. 3D navigation interface

Benefits

The first section of the interview discussed the benefits of IL experiences, and most students found them inspiring and unique. They had an engaging interaction with the content, and the simulation videos gave a realistic feel, helping them learn abstract concepts easily and the minute details. They also performed well on their assessments.

Main Theme 1: Inspirational and Unique. They expressed feelings of happiness and excitement when exposed to IL environments. The learning experiences provided through IL environments were considered so unique by the students that they said they cannot be compared to or achieved in traditional classroom setups.

Subtheme 1.1: Unparalleled Interaction. The students reported actively learning throughout the IL environments and easily understanding several complex and abstract concepts. Further, the simulated videos had several opportunities to interact and engage deeply with the content. Participant 9 explained, **"**I could not trust how realistic everything there . . . I felt in the virtual reality immersive learning environment. I was able to visualize complex concepts on climatic changes and understand them better. For example, while exploring the planet Earth."

Subtheme 1.2: Realistic Experience and Beyond Imagination. Participants explained that when immersed in the virtual reality scenario, they were completely oblivious to external disturbances and what was going on around them. In addition, they expressed curiosity and a desire to know what comes next. Participant 2 stated, "This is simply unimaginable . . ."

Subtheme 1.3: Motivates to Learn. Participants felt highly motivated as they progressed through each stage of the IL environment. Students reported higher retention than in traditional learning settings. They revealed that IL environments enhanced their ability to think creatively and critically, as well as their attention span and comprehension. IL environments helped them visit places that are generally inaccessible, such as Mount Everest. Similar results are reported by other researchers as well (Pollard et al., 2020). Participant 10 exclaimed, "[it] was mind-blowing! I felt like I am exported to a very different world . . . was able to explore geographical nature of the places, interact with virtual objects, and even conduct experiments in a virtual laboratory."

Drawbacks

Students were apprehensive about using the VLE. They worried it would affect their eyes, ears, brain, body posture, etc. They found themselves less dependent on the device than in their self-study at a library or reading by themselves. Furthermore, students expressed that they may not be able to discuss with their friends while using a headset to learn. Students also felt that this setup is expensive for large-scale implementation and requires internet access, headsets, software, training materials, and trained teachers.

Main Theme 2: Addiction and health. Many students reported wanting to learn subjects such as social science, environmental science, and sciences (Physics, chemistry, biology), as well as geography. A few of them believed that regular use of VLE may strain their sensory organs, such as the eyes, ears, back, and brain. Some of them mentioned they were just overwhelmed and wanted to learn everything from it. Participant 10 asked, "Can we learn mathematics also in it?," and Participant 3 stated, **"**I wish to learn everything like this."

Subtheme 2.1: Sensory Strain. Students mentioned that some parts of the videos were blurred at times due to low bandwidth or other technical issues, which caused eye strain. Participant 8 stated, "I experienced low resolution videos…I don't know the reason." Furthermore, some of them reported that prolonged use of the headset screen caused dryness and fatigue. Participant 2 complained, "Even after I removed the headset, I felt I am hearing the humming sound." Some students even mentioned there were audio disturbances and a humming sound throughout, causing a slight headache. A few of the pairs mentioned that they needed to constantly focus, as there was no break unless they paused. Some even reported back pain from constant use of the device. Participant described, **"**I felt a neck discomfort and heaviness, it is like I am tied with something."

Subtheme 2.2: Addiction. Many students said they would learn almost all subject content very well using a VR camera. It was easier for them to watch and learn than to read a book or notes. Students mentioned that, as it gives a realistic view of the subject content, it is more engaging for them than regular classroom teaching. Participant 1 explained, "I am just enjoying learning out of it . . . time just flew by." The embedded reward system in certain gamified videos further captured their attention, as Participant 5 described: "I almost got all [the] rewarding points and prompts." A few even mentioned that they were somewhat dependent, psychologically and behaviorally, on learning through VR material; however, it sounded unrealistic to them. Participant 4 exclaimed, "Oh my god . . . I am almost addicted to learning from VR . . . I started feeling frustrated with other traditional classes, and was thinking why not all do it in virtual learning environments."

Subtheme 2.3: Curtail Social Life. Almost all students mentioned that if they used it for all classes, peer interaction would not happen, and they could not socialize. Participant 6 explained, "I am just lost in another world." Students also noted that striking a balance between VR-enabled classes and an after-class discussion hour could create more space for socializing and be academically rewarding. Participant 8 suggested, "teachers can create a collaborative assignment, though."

Participants suggested several ways to improve the experience: Students revealed that providing them with VR content aligned with their curriculum or syllabus would help them learn independently and share/discuss it with their classmates after class hours. Furthermore, schools could provide a VR lab facility, high-bandwidth internet, VR camera video materials, and ensure that teachers know how to use VR for seamless teaching and learning.

Main Theme 3: Collaborative Features. Some of the students mentioned that if multiple people could enter a shared 3D space at the same time for topic learning, it would be more fun. Some students even mentioned that more gamified content would include collaborative features, such as creating avatars with real-time voice and gestures. Participant 5 remarked, "I will be in my favorite Halloween costume." Some even said, just like a video game, real-time collaborative tools will be fun for learning. Participant 7 added, "My collaboration with [the] Russian chap was amazing." A few of the students even offered innovative ideas, like going on a simulated field trip and using graphs to show each participant's progress, just like in video games, which will bring more competitive spirit to learning.

Subtheme 3.1: Collaboration. Students felt that introducing peer collaboration might help improve learning, while it might also disrupt their attention span. In certain training courses, VR can provide psychosocial and emotional experiences if the simulated content creators capture them. Students shared that an assignment based on the VR content can bring more collaboration. A few of them said that working on a collaborative assignment will be challenging and, at the same time, motivating.

Subtheme 3.2: Content Aligned with Curriculum. Most students agreed that if the VR classes were aligned with the syllabus, they would be more productive and valuable. Participant 3 explained, "I just feel the whole world must have common syllabus and common learning material." Students said they were now learning a few common topics across the countries; however, the ways each country's students understand them are overwhelming, and adaptation must be at the forefront for quality academic engagement. Participant 7 remarked, "Give me a VR headset and the videos, I am done with learning."

Subtheme 3.3: 3D Navigation Interface. Some students found navigating 3D interfaces difficult and time-consuming, leaving little time for knowledge acquisition. Participant 7 explained, "I believe incorporating more interactive elements into virtual reality experiences would enhance the learning process. For example, including quizzes or challenges within the virtual environment that require active participation and problem-solving skills." Similarly, Participant 1 added, "It would be great to have more realistic simulations in virtual reality, such as realistic physics and accurate representations of objects and environments. This would make the learning experience more immersive and engaging." To add further, Participant 9 stated, "It was amazing, but sometimes the technology glitches (buffering time) are frustrating. It interrupts the flow of learning and makes it difficult to stay engaged...there is a need for seamless video content creation with 360° and 3D effect…

A recent study did make the same observation (Makransky, 2019). There is a need for good internet bandwidth for a seamless IL experience. Therefore, newer technologies could improve efficiency and reduce processing time.

Data Triangulation

To address data triangulation (Flick, 2018), as per the quant-qual sequential explanatory design, the researchers conducted qualitative interviews to provide more in-depth evidence to support the quantitative results. Accordingly, the study's qualitative outputs revealed that students who scored high on the positive IL experience scale expressed more favorable attitudes towards IL experiences. They cited multiple benefits during their intervention, such as learning abstract concepts becoming easier for them, learning experiences being realistic, and their attention and interest being captured throughout the intervention. They wanted to learn every subject in this mode. They also reported increased class participation and enjoyed interacting with video content, as evidenced by the narrative analysis results. The quantitative analysis revealed a correlation between IL experiences and attitudes toward the environment among internationally paired higher secondary students. The high positive correlation is evident in the theme and subthemes that emerged out of narrative analysis, such as (1) unparalleled interaction, (2) realistic experience and beyond imagination, and (3) motivation to learn.

Furthermore, the regression analysis accounted for 43.5% of the variation in attitude towards the IL environment among the study participants. This is again evident from the narrative thematic analysis theme and subthemes, with students even expressing how to improve this experience for the benefit of the student community in the future, and how it can be further strengthened creatively. These expressions have arisen from the reinforcing experiences they had during the intervention, and the quotations from the semi-structured interview further reinforce their accountability towards IL environments. Overall, the qualitative results explained the quantitative results in greater depth, as intended by the study.

DISCUSSION

As intended, the study found the immersive virtual learning experiences of internationally paired senior secondary school students from India and Russia. Students from both countries had a satisfying immersive learning intervention as revealed by the descriptive statistics. Furthermore, they even developed a favorable attitude towards immersive learning technologies and the environment. There existed a strong positive correlation between IL experiences and attitude towards the immersive learning environment. A recent study by Huang et al. (2023) found multiple relationships with psychological outcomes. The simple linear regression test revealed that there was almost a 43% variation in attitude towards IL from their IL experiences during the intervention.

Additionally, qualitative analysis complemented the quantitative results by identifying main themes and subthemes on the benefits and improvements of VR learning technologies to strengthen the IL experience. A systematic review study by Conrad et al. (2024) found that IVR has positively impacted learning and student engagement, as observed in the present study. The present study even detailed the possible drawbacks of learning from VR technologies as revealed by the participants. Apart from reporting a unique and unparalleled learning experience, participants also noted a few drawbacks, including eye fatigue, eye strain, ear strain, cognitive overload, issues with the technology's audio, nausea, and dizziness. A recent study by Ratan et al. (2025) reported fatigue associated with longer hours in VR classes. A study by Pollard et al. (2020) found that deeper immersion may affect learners' performance. Contrastingly, a recent study, like the first theme of the present study, reports that the immersive learning environment is inspiring, unique, and unparalleled by any other virtual experiences (Parong & Mayer, 2018). The present study reported that, as VLE demands immersion using a VR camera, the classroom social interaction among peer groups may gradually decline (Ratan et al., 2025).

Furthermore, reliance on IL environments for learning may lead to health issues. A recent study revealed that increasing social interaction may reduce cybersickness (Yang et al., 2023). Interestingly, a recent study reported that exaggerations and unrealistic content can mislead the conceptual understanding (Kavanagh et al., 2017). Thus, authentic content validation is essential in edutainment. It is difficult to produce compatible content packages that support all VR software in a rapidly changing digital world (Frazier et al., 2019). Students across the world have been drawn to mobile gaming and subscription to state-of-the-art technologies; Metaverse education may be another addition to this. More research in the health sciences is needed on the hazardous effects of edutainment. Therefore, balancing leisure-time activities using technological devices is crucial and should be done by both teachers and students.

Thus, the VR learning environment in an internationally collaborative context provided positive learning experiences. Students could construct their subject-specific knowledge as guided by Vygotsky's cognitive constructivism theory. The participants' experiences clearly indicated acceptance of VRL environments as a better learning pedagogy, as implied by Davis's technology acceptance theory. Overall, the results of the present study reinforce the idea of international collaborations in academia through a progressive education perspective.

A few limitations of the study are that we had to limit the sample size due to various barriers, such as the number of English-speaking students, willingness to participate, the infrastructure required, and the need for a manageable cohort size. The study had to limit itself to the selected grade level to match the course content.

CONCLUSION

The present study achieved its objectives. The study successfully measured the IL experiences and attitudes of internationally paired senior secondary school students towards the IL environment. Almost 75% of the student pairs had very positive IL experiences through the virtual reality IL intervention, and their attitudes towards the IL environment were positive. The study observed a high positive correlation ($r = 0.664$) between their IL experiences and attitudes towards IL environments. The regression analysis showed that 43.5% of the variation in attitude is due to the student's IL experiences. The study used triangulation of quantitative and qualitative outputs. Participants clearly agreed that the learning experience from the IL environment, especially in the internationally collaborative context, is truly unparalleled by traditional learning experiences. The limitations are the nature of the sample and its cultural background. The researchers recommend that future researchers develop indigenous Metaverse pedagogy, create teacher-training content on teaching through IL experiences, develop seamless 3D interfaces to support IL environments, and leverage the benefits of IL environments with artificial intelligence and generative AI for teaching and learning. In addition, research on motivational aspects, emotional changes that drive student engagement, behavioral patterns in IL environments, and adaptations brought about by students provides a rich source for future studies.

CONFLICT OF INTEREST

Authors and participating universities have no competing interests. The study is part of the first pilot collaborative research project, the success of which will lead to long-term collaboration between the universities. We sincerely thank all the participating students and teachers from Russia and India.

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