



Immersive Learning Environments in Education: Application, Effect and Challenges

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The objectives of the present study are to search and critically analyse the immersive learning environments; and deriving the applications and effects of immersive learning environment in education with suitable examples by supporting empirical evidences. Based on the objectives and limitations of the present study, important research questions for critical analysis are formulated. The "Substitution Augmentation Modification Redefinition Model" (SAMR) of Dr Ruben Puentedura was used as the theoretical framework. The study is review-based and analytical in nature, where related literatures regarding the uses, effects and challenges of immersive learning environments in education in present and futuristic perspectives. Both inclusion and exclusion criteria were followed. From the intensive literature review regarding the immersive learning environments widely used in educational setting, the four important aspects were found, viz. immersive learning, virtual reality, augmented reality and mixed reality. The results revealed that ILEs have wide educational effects like providing learning autonomy, increasing attention, providing permanent learning, self-regulated learning, active participation, increasing comprehension of lesson, providing in-depth learning etc. in terms of cognitive effects. ILEs have some affective effects of students like satisfaction, fun,

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curiosity, enjoyable, interesting, exciting, motivating etc. After the critical analysis of the immersive learning environment systems used in education, game-based learning, project-based learning, experiential learning, collaborative learning etc. were found to be most frequently used. So far as its implementation part is concerned, some sorts of challenges have been noticed in research studies i.e., difficulty in understanding, technical problems, insufficient instruction, limited time, and health problems. Suggestions for further research were provided.

Keywords: Immersive technology; immersive learning environment; virtual reality; augmented reality.

1. INTRODUCTION

Man is a social animal, who lives in the society. Human life is full of learning, experiences and new knowledge based on time and place. It is the reasoning capacity that makes them different and unique than the other living creatures. Learning plays a significant role for all the individuals including teachers, students, working professional etc. It may be defined as a process of developing insight into the knowledge, understanding, behaviour, skills, and experiences that is acquired and constructed by the human beings [1]. Several techniques have been developed to develop the learning and knowledge of the human beings day-by-day. Some kinds of learning are revealed to be immediate which are induced by a single event and some are deduced from existing events or experiences. Through learning, a change in human behaviour is noticed which lasts for life-time because of much knowledge and skills accumulated from reconstructed life-experiences [2]. Research study reveals that human learning starts before the birth of a child i.e., inside the mother's womb [3] and it continues till the end of life. Human beings learn a lot and develop the boundary of knowledge through ongoing and continuous interaction among people, social learning environment and other relevant factors. Learning is a natural, situational and environmental event, which is affected by several factors. But, so far as learning is concerned, the learning environment plays the most significance role in this regard. The term learning environment may be described as a situation for the occurrence of teaching and learning in educational and cultural context, which is alternative to the concept of 'classroom'. In most typical sense, learning environment can be defined as the educational context based on knowledge and experience of the students where learning occurs encompassing varieties of learning cultures. Learning environment in social context refers to the culture of the population, where learning occurs in a social setting. But it is true that learning environments are highly

diverse in nature, which is deeply influenced by learning styles, institution, culture, organisation, thinking, behaviour, working culture etc. From the educational perspectives, learning environment is highly influenced by the operational characteristics of the teachers and the experience of the students including pedagogy, learning styles, and several internal-external factors [4]. Traditional model, progressive model, constructive model, technological model and skill-based models of education are the several educational models developed throughout 20th and 21st century upon which the learning is based on. Each model of education has its own significance in different context. Taking into account the technology-based learning model, Immersive Learning Environments (ILEs) have been developed to make learning more joyful, interesting and active. In educational and other fields IMLs have been recently prevailing and developing [5].

Immersive technologies stand between virtual and augmented reality i.e., virtual and real world [6]. In order to visualise important abstract concepts in education and engage the learners in real-life learning experience the ILEs in education has been incorporated systematically [7]. The use of these immersive technologies develops special skills among the students which becomes very difficult by using the traditional teaching methods [8], along with that these technologies also increase student's participation in study [9] and active engagement [10].

1.1 Theoretical Framework

SAMR Model: In the present study, "Substitution Augmentation Modification Redefinition Model" (SAMR) of Dr Ruben Puentedura [11,12,13] was used as the theoretical framework. The SAMR model examines the use of technology in teaching and instructional activities. This model enables the teachers for developing their reflection on technology integration and critically evaluating technology integration related activities as one of the most important sources of

learning experience. This model is closely related with developing learning outcomes of the students based on their diverse needs and expectations as revealed in research study [14].

The figure depicts the SAMR model of teaching along with its four important elements. The overall model is based on two important technology tools i.e., enhancement tools and transformation tools covering the first two steps and last two steps respectively. The first step in the enhancement level is substitution, which is used as a direct tool which is used as substitution of analog version, which does not include any kind of functional change. Example: use of math games. The second step is augmentation which refers to the functional improvement of tool and direct substitution. Example; game-based learning. In the transformation level, modification is the first step which needs reflection and it brings definite change in teaching by redesigning the teaching task. Example: virtual laboratory. The second step of transformation level is redefinition, where we can notice clear cut transformation and active learning as here the use of technology is done to create new tasks. Example: use of immersive technology, use of interactive learning tools etc [15]. This SAMR model of teaching was taken as the theoretical framework in the present study, where related literatures regarding the immersive learning environment were collected and critically analysed, from which the application and effects of immersive learning environment were derived along with the challenges in its implementation part. This model was taken as theoretical

framework for the present study, as this model fits with immersive learning.

From the intensive literature review regarding the immersive learning environments widely used in educational setting, the following four important aspects were found, viz. immersive learning, virtual reality, augmented reality and mixed reality [15].

Immersive Learning: In most simple way, immersive learning may be defined as the learning which is possible through the use of immersive technology [16], but technology - based learning and learning is distinguished from the effects that it creates [17]. According to Kuhail et al. [15], immersion means 'technological elements of a medium its emerging response'. Use side (learning through presence) and supply side (educational medium) are the two basic elements of immersive technology [18].

Virtual Reality: In simple sense, virtual reality can be defined as a process of creating artificially simulated experience by taking different form of real-world situation by taking the totality of software and hardware technologies [19].

Augmented Reality: Along with virtual contents augmented reality system is blended with real imagery in a real time user interaction with the system [20]. Marker-based and markerless are the two types of augmented reality. Along with these two types, location based augmented reality is also widely used.

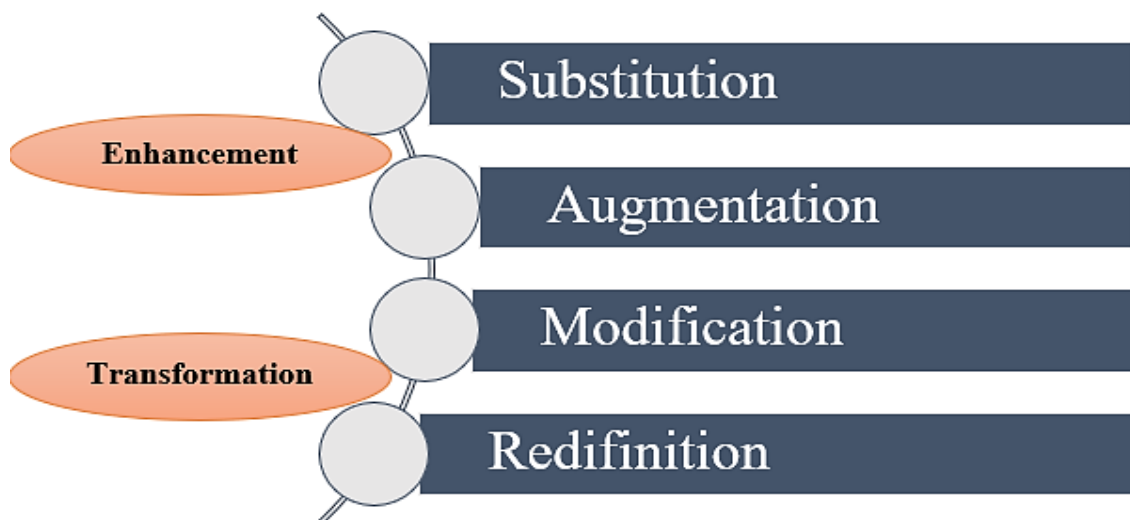


Fig. 1. The SAMR model of teaching (Source: Puentedura [12])

Mixed Reality: Mixed reality is one kind of emerging immersive technology developing throughout the world. But it is very difficult to distinguish augmented and mixed reality [21], as researcher considers mixed reality as a sub-set of augmented reality [22]. However, according to Speicher et al. [21], "Mixed reality takes augmented reality further by allowing users to walk into and manipulate virtual objects shown in the real world".

So far as the interaction techniques of immersive technologies are concerned, it can be said that learning tasks can be performed and conducted in virtual 3D environment or in real environment based on the interaction between human beings and computer [23].

2. METHODOLOGY

The study is review-based and analytical in nature, where related literatures regarding the uses, effects and challenges of immersive learning environments in education in present and futuristic perspectives were collected. The keywords like "immersive learning", "immersive learning environment", "virtual reality", "augmented reality" etc. were used and related literatures from different databased like SCOPUS, Web of Science, ProQuest, Google Scholar, ResearchGate, ERIC etc. were collected. Before selecting the final articles for review analysis, some inclusion and exclusion criteria were followed. The primary and secondary research studies published in English language and related to education were included for the final analysis. Effort was made to include the recently published research papers (2015 onwards) in indexed journals. The articles not fulfilling the norms of inclusion criteria were not taken into account. However, posters, review papers, technical reports, Ph.D. thesis or tutorials etc. were excluded. After the collection of related studies, the research protocol like research objectives, questions, searching plans, criteria etc. were defined for the present study.

The objectives of the present study were to search and critically analyse the immersive learning environments; and deriving the applications and effects of immersive learning environment in education with suitable examples and support of empirical evidences. Based on the objectives and limitations of the present study, the following important research questions for critical analysis were developed.

RQ1- What are the immersive learning environments used in education?

RQ2- What are the applications of immersive learning environment in education?

RQ3- What is the effect of immersive learning environment in education?

RQ4- What are the challenges in implementing immersive learning environment?

The first research question examines the examples of immersive learning environments widely used in educational setting with supporting evidences. The second question deals with the critical analysis of the application part of the widely used immersive learning environment in education. The third question examines the effectiveness of immersive learning environment in education through meta-thematic approach. The last question of this study examines the challenges in applying immersive learning environment.

3. RESULTS

3.1 Critical Analysis of Immersive Learning Environment in Education: An Overview

RQ1- What are the immersive learning environments used in education?

The first research question examines the examples of immersive learning environments widely used in educational setting with supporting evidences. In this regard, Kuahail et al. [15] surveyed immersive learning experiences through secondary data by analysing recent evidence-based research studies. They critically analysed 42 research paper on immersive learning experiences in education by taking into account seven important dimensions i.e., "application field, technology used, educational role, interaction techniques, pedagogical strategies, evaluation methods, and challenges". They found that most of the related studies covered Science, Technology, Engineering and Mathematics (STEM) related topics. The study also revealed that immersive learning experiences are widely used in USA as compared to other countries, and its usages are increasing gradually. Akgun & Atici [24] critically examined the immersive virtual reality-based environments as a predictor of student's academic achievement by applying meta-analysis and meta-thematic approach. The content analysis and meta-analysis of the

research studies revealed that ILEs have wide educational effects like providing learning autonomy, increasing attention, providing permanent learning, self-regulated learning, active participation, increasing comprehension of lesson, providing in-depth learning etc. in terms of cognitive effects. ILEs have some affective effects of students like satisfaction, fun, curiosity, enjoyable, interesting, exciting, motivating etc.

Kesim & Ozarslan [25] undertook research study on different types of immersive systems widely used in educational setting, viz. HMDs, 3D models etc. Along with this, the study explained and discussed the augmented reality systems i.e., 'enablement of real-world and collaborative task'. Related to this research also indicated desktop computers as usable for providing learning experiences based on augmented reality [8]. Simulation and training are also other applications of immersive learning environment used for educational purposes [26]. Research also revealed that virtual immersive learning systems has been used in different domains of education like computer science, engineering, physics, astronomy, chemistry, biology, mathematics, medicine, art-science etc [27], this study discussed 'game-based learning' and 'experiential learning' as examples of immersive learning system. Along with all these, other pedagogical principles of ILEs included collaborative learning, activity-based learning, architectural pedagogy and scaffolding [26,28,29,30].

After the critical analysis of the immersive learning environment systems used in education, the following important aspects were found as common in most of the studies.

- **Game-based learning:** This method used learning games as a medium for defining and supporting students' learning in a game-based learning environment. It develops academic engagement and active participation among students.
- **Experiential learning:** It refers to an experiential training method to teach students by the use of virtual reality for simulating real-world scenarios and engaging students in an immersive environment.
- **Simulation-based learning:** It refers to a form of experiential learning which provides real-world experience to the students, and develop the boundary of their knowledge and skills in a most suitable simulated environment.
- **Collaborative learning:** It refers to a learning environment where the students work and learn together in a group about different tasks with active participation.
- **Activity-based learning:** It refers to a learning environment where the students perform some activities and learn in a group.
- **Project-based learning:** It refers to one kind of instructional approach which is designed for the students for developing their knowledge and skills by engaging them in project-based activities surrounded with problems and challenges.

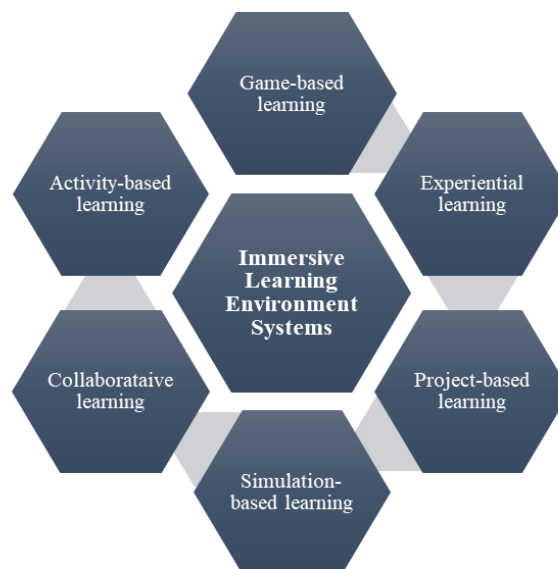


Fig. 2. Different types of ILE systems (Source: Compiled by author)

3.2 Applications of Immersive Learning Environments

RQ2- What are the applications of immersive learning environment in education?

So far as the applications of ILE systems in education are concerned, the research studies revealed that ILEs have wide educational benefits concerned to developing motivation among students, improving learning outcomes, encouraging active-learning, facilitating social learning and fostering imaginative skills [8,26,29,30]. ILEs for educational purposes have four important features i.e., sensory, narrational, actional and social [31]. According to Akgun & Atici [24], immersive learning environments has some special features regarding its application i.e., useful in multi-dimensional context, provides a safe learning environment, provides a flexible environment, provision of interactive learning environment, time saving, removal of time-space limitation, provision of feedback, setting a standard in learning, chances of applying knowledge in real-life situation. Research studies related to the applications of immersive learning environment have been examined by applying experiments, questionnaire, evaluation, interview, and field observations [15]. Experimental studies about the applications of immersive learning environment in classroom context revealed significant results for improving academic performance [32,33,34], and also it develops learning satisfaction while engaging in augmented reality-based learning environment [35]. The research studies based on applying questionnaire tool revealed that immersive learning environments is positively perceived by the students in terms of improving their performances, motivation for learning and doing any kind of academic tasks, and academic engagement [36]. Evaluative study [37] and field observation Nordin et al. [38] study on immersive learning environments revealed subjective satisfaction, learning engagement, usability, flexibility in learning, interactive etc. as the benefits of ILEs in educational setting.

It is a fact that immersive learning activities help the students for engaging in a learning environment where the students actively participate in learning-related activities. So far as the implementation of immersive learning is concerned, it is suggested to take care of four important aspects i.e., engagement, effectiveness, performance tracking and spatial designs. As these learning environment is based

on developing student's knowledge, so adopting such technologies and implementing in educational setting is highly beneficial now a day as we live in an era of technology.

From the analysis of the applications of immersive learning environment in education, it is vivid that it has wide educational applications in different aspects of education.

3.3 Effectiveness of Immersive Learning Environments

RQ3- What is the effect of immersive learning environment in education?

Empirical studies related to the effect of immersive learning environment reveals mostly significant positive results. The meta-analysis results of virtual reality environment revealed that it has game-based virtual reality showed significantly positive results on K-12 and tertiary level student's achievement as compared to simulation and virtual worlds [39]. North & North [40] examined virtual reality-based environment and revealed its sense as high. The study of Tepe [41] also revealed high sense of presence of virtual reality environment, and along with this it also found virtual reality environment as a significant predictor of student's learning and professional skills too. So far as the effects of virtual learning environment on physics lessons of 8th grade students are concerned, research revealed significant results in terms of academic performance and motivation [42], similar study also revealed significant results in terms of increasing student's interest and motivation in an individual learning environment [43]. The study of Chein et al. [44] also revealed significant results of virtual learning environments on developing critical thinking and motivation among students and decreasing anxiety among them. So far as the academic success and satisfaction among students are concerned, the virtual learning environments also showed positive results [45]. Akgun & Atici [24] conducted a meta-analytical and meta-thematic study to gain understanding regarding the effectiveness of immersive virtual reality environments in terms of academic performance of learners by following a mixed design. The study revealed a moderate positive effect of ILEs on student's academic success, and along with these, the meta-thematic analysis revealed significant effects in cognitive, affective and psychomotor skills of the students and several academic benefits. Liu et al. [46] conducted a study on immersive virtual reality

classrooms and its effect on the academic success of primary school students in science lessons through mixed-method approach and revealed significant effects in terms of academic success and motivation among students. the study also revealed that immersive virtual reality environment reduces cognitive loads among students. Almufarreh [47] explored the significance of mixed reality environment in fostering learning experience of students and their academic achievement by applying quantitative research design and revealed significant positive results in favour of mixed reality-based on experiential learning and interactivity. Sviridova et al. [48] conducted an experimental study to gain understanding about immersive technologies as a medium to develop academic success and learning motivation of students studying in higher educational institutions and revealed effectiveness of immersive technologies at university level.

However, a smaller number of studies were found concerning the effectiveness of immersive learning environments on student’s academic achievements. However, the critical analysis of the recent literature the focus areas of the effectiveness of immersive learning environment were found as depicted in the following figure.

Virtual reality environment and immersive learning environment are the widely studied areas in different disciplines; but so far as its effectiveness is concerned most of the studies examined the same in terms of students’ academic achievements, satisfaction, motivation, critical thinking, cognitive, affective and psychomotor skills, and professional skills.

3.4 Challenges in Implementing Immersive Learning Environments

RQ4- What is the challenges in implementing immersive learning environments?

Immersive learning environments have wide educational implications in present and futuristic perspectives, but so far as its implementation part is concerned, some sorts of challenges have been noticed in research studies i.e., difficulty in understanding, technical problems, insufficient instruction, limited time, and health problems [24]. Apart from these, research studies reveal several challenges and limitations that hinders the implementation immersive learning environment in the field of education viz. discomfort [49], inadequate tracking [50], lack of tutorials, inadequate vision Erofeeva & Klowitz [51], difficulty in handling equipment [52], and limited interaction [53].

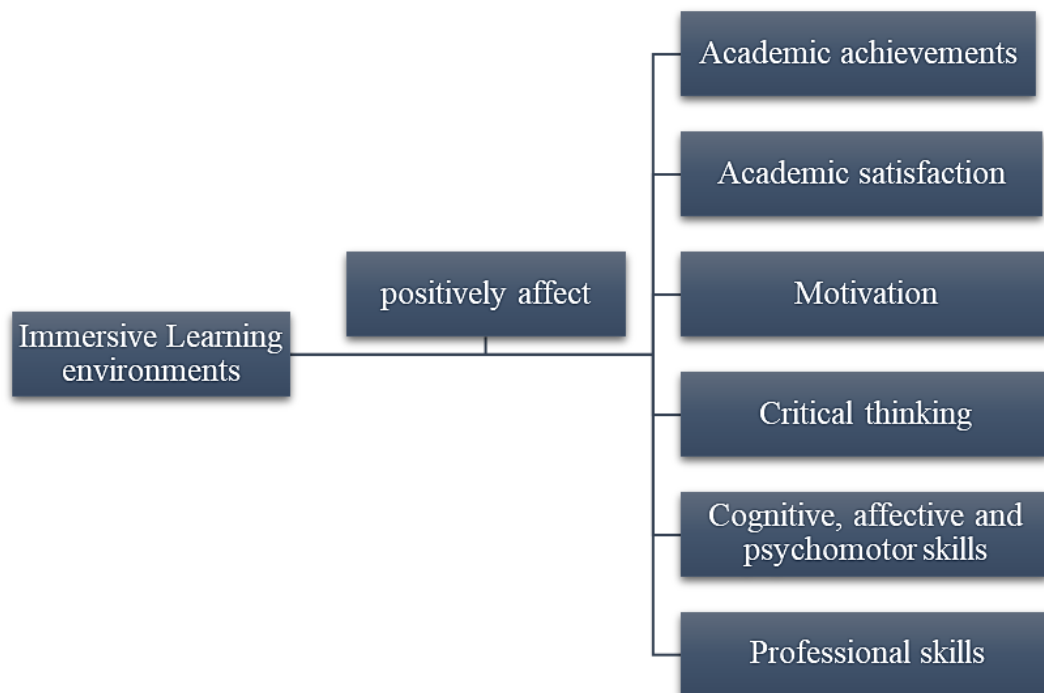


Fig. 3. Focus areas of effectiveness of ILEs



Fig. 4. Challenges in implementing ILEs

Besides having positive impacts of immersive technology in education, several challenges are noticed in its implementation part. Out of different challenges, lack of proper awareness among the stakeholders of education is one of the most important challenges, and in this regard digital divide can also be a challenge as the ILEs are based on the use of educational technology too. On the other hand, virtual reality-based tools are very expensive, so all the educational institutions may not afford the same. Similarly, supports of parents and other stakeholders of education for the implementation of immersive learning technology is also one of the challenges in this regard. For immersive learning environment traditional methods are not employed, and it becomes a challenge to develop and assess the essential methods like performance-based evaluations as aligned with the immersive learning. The cost and resource requirement is another challenge for immersive learning in education as it relies on advanced expensive technologies like VR and AR equipment. Accessibility and implementation are other challenges of ILEs both in micro and macro level of education. Some of the stakeholders of education resist to change their mind set for using ILEs and adopt new technologies, so its another challenge in this regard. Having proper collaboration with stakeholders in implementing ILEs may also be a challenge in Indian perspectives.

4. DISCUSSION AND CONCLUSION

The SAMR model of teaching was taken as theoretical framework in the present study, and in this regard the analysis of related literature revealed that most of the study have been conducted in augmentation level followed by others. So far as the pedagogical strategies used in immersive learning are concerned, it was found that game-based learning, collaborative learning, project-based learning etc. were most frequently used strategies in educational setting. The critical evaluation of the literatures made it clear that immersive learning environments have relevance in present context as it has wide educational implications in terms of improving student's academic performance, engagement and participation, motivation, satisfaction etc. So far as the effects of immersive learning environments are concerned, almost all the experimental and survey studies revealed significant positive effects in terms of cognitive, affective and psychomotor domain of student's learning. The available literatures made it clear that immersive learning environments are the most powerful educational tools widely applicable to improve the quality of education. The meta-thematic analysis of some literature also revealed that immersive learning environments with virtual reality has potential to foster psychomotor skills, technical skills and other related skills among the students [54]. Apart from these,

the immersive learning environments have resulted some negative outcomes in terms of increasing dizziness, nausea, insufficient sound issues, anxiety, headache, fatigue etc. among the users [55,56]. However, other challenges and problems in the implementation of immersive learning environments were also found, which needs to be given attention, and in this regards further research studies can be conducted for effective implementation of immersive technology particularly in Indian context, as very less number of studies were found in India.

As from the analysis of related literature it was found that most of the studies have been conducted in STEM, so further studies may be conducted in other areas like arts and humanities. Further experimental and survey research can be undertaken taking into account the other related variables with immersive learning environments. Conceptual frameworks can be developed by conducting further research studies on immersive learning environment from the context of its implementation could be derived in terms of classroom settings. Less number of studies were found in school context, so it is recommended to conduct further research studies in school and other levels of education. The significance and relevance of ILEs are undeniable in education sector at different levels. Finally, it can be concluded that immersive learning environments have significant positive results in educational setting, so stakeholders of education should be encouraged to use it in classroom context as power tool of improving student's academic progress in qualitative perspectives.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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