The Influence of Immersive Virtual Reality (IVR) on Skill Transfer of Learners: The Moderating Effects of Learning Engagement

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Abstract—Immersive virtual reality (IVR) is a full integration of virtual simulation and reality through computer engines and digital technologies. In particular, upon entering the field of education, IVR triggers the comprehensive reform of the education industry, realizes the interaction between virtual and real worlds, shapes a more highly immersive teaching scene, and meets the personalized needs of different learners. Thus, exploring the transfer of learning skills under IVR and traditional teaching modes is of great significance to understanding their causal relationship. Results show that training methods have significant differences in post-test scores. Immersive virtual experimental teaching plays a significant role in the skills transfer of learners, and learning engagement has a significant moderating effect in the above relationship. In this study, the results have important reference value for enriching the design of immersive teaching content, improving its design of translation, and promoting the skills transfer of learners to higher-order thinking knowledge.

Keywords—immersive virtual reality (IVR), skill transfer, moderating effect

1 Introduction

At present, China is vigorously promoting the development of education informatization, and different learning groups are gradually accepting richer and more personalized teaching methods. Under an extremely rapid update cycle, knowledge breaks the limitation of time and space, and learners can acquire new knowledge and skills anytime and anywhere according to their own needs to supplement their deficiencies. This scenario is the inevitable future trend of education development. Especially under the influence of ubiquitous learning, artificial intelligence, 5G information technologies, and other emerging technologies, the education industry needs to determine suitable teaching modes, update teaching methods, and constantly update software and equipment to achieve the desired effect. China attaches great importance to the development of education informatization. With the support of national policies, the digitalization and virtualization of resources are some of the important forms of education in the future. Currently, China has begun to fully implement the construction of

virtual practice teaching base. Various provinces have also issued corresponding measures to accelerate the integration of virtual reality information technology into daily teaching. Thus, the monotonous traditional teaching mode can be supplemented by fully integrating virtual reality technology into the daily teaching of schools at all and types, enriching the characteristics of teaching scenes, improving the experience of learners, stimulating learning motivation and student interest, and finally comprehensively improve the teaching quality of teachers and the learning performance of students.

At present, virtual reality technology can be explored and discussed from two aspects of Immersion and Presence, to establish the starting point of research. Among them, the more important is the extensive application of immersive virtual reality technology in the education industry, which can enable learners to obtain a more comprehensive learning experience by using helmets, projection, and other ways to create a virtual world that can be truly experienced. By integrating more colorful multimedia education and teaching resources, and cooperating with good operating equipment, learners can perceive various teaching environments through comprehensive listening and feelings, realize deep interaction with the virtual environment, and improve their learning performance. Learning engagement is also a key factor affecting such performance, in terms of the degree of difference among learners in a virtual environment. Analyzing these differences can more scientifically explore behavior patterns and cognitive strategies with enlightening value, which is helpful to understand the mechanism of the learning effect. Until now, most colleges and universities in China have established virtual reality laboratories, encouraged teachers to carry out virtual experimental teaching. In several courses supported by immersive virtual reality teaching, skills transfer can be achieved using several input devices to simulate and interact with objects in virtual scenes. Virtual experiments can effectively solve a series of problems in ordinary colleges and universities, such as insufficient experimental resources, out-of-date equipment, and potential safety hazards during experimental operation. These virtual supplements can not only effectively reduce experimental costs but also improve efficiency of experiment, stimulate learning interests and participative enthusiasm of students, improve learning efficiency, ensure the innovation of teaching content, and show off the skills transfer of learners.

2 Literature review

IVR teaching mainly places learners in an environment of immersive teaching hardware and software. Learners interact through equipments, complete corresponding experimental operations, obtain data, and actively explore the learning of internal development regulation. Immersive virtual experimental teaching can stimulate endogenous motivation, improve skills transfer, and enable more intense teaching presence in a more colorful virtual environment such that learners can acquire a higher level of technical skills. As for how IVR teaching can improve the learning performance of learners, Psotka [1] was the first to introduce virtual reality technology and its application in education training, thereby outlining the existing research on virtual

reality. Bossard et al. [2] demonstrated that virtual learning environment can be used to develop skills, and discussed how new ideas in cognitive psychology can influence and promote learning transfer. Ganier et al. [3] found that virtual reality can provide new opportunities for training on operators who engaged in complex tasks. The ultimate goal of virtual training is to transfer the knowledge acquired in a virtual environment to a real one, and results indicate that experimental groups in virtual environment can achieve higher performance level than other groups. Dolgunsöz et al. [4] adopted a step-by-step exploratory approach, and found that virtual reality experience does not affect short-term writing performance, but becomes promising in the long term because of most learners like VR. Lin et al. [5] adopted a non-equivalent pre-and post-test design model and found that virtual reality education can promote optimal creativity and leadership among 104 students in two classes of Taiwan Changrong Christian University. Samadbeik et al. [6] found that the use of virtual reality can improve learning effect. Subjects who accepted virtual reality training have higher performance level in medical practice, and the application of such ability plays an important role in improving the performance of different medical groups. Chae et al. [7] found that, through evaluation and questionnaire survey, participants using virtual reality can better understand and learn the required training content than those in the control group. In addition, learners prefer to train them with VR. Kim et al. [8] conducted an experimental study on apprentices of gardeners to investigate the proportion, composition, and creativity of IVR interface and paper sketching as well as the behavior of learners compared with design results. The effectiveness of design quality improved when students performed IVR after their completed drawings, and the sequence had more effective results in terms of proportion and composition. Schofield [9] believed that learners can obtain varying experiences and lessons under interactive VR learning environment. Soto et al. [10] applied virtual reality platform "Immerse-Me" to oral English learning for college students, and demonstrated that the advantage of immersive reality teaching lies in placing students in the virtual environment of the second language, improving different skills of English as a foreign language, and promoting the motivation of students to learn spoken English. Merchant et al. [11] adopted experimental or quasi-experimental research design and learning results to evaluate teaching effects based on virtual reality. Games, simulations, and virtual worlds and other teaching methods were found effective in improving academic performance. Meyer et al. [12] used the samples of 118 participants to test whether courses presented in immersive virtual reality or video can benefit from principles before training, which revealed an interaction between media and methods, and the positive effect of pre-training on knowledge. Rau et al. [13] analyzed the effect of virtual reality and augmented reality (AR) on fast reading in education, and found that learners tend to choose approximately 10% more time on VR and AR than on desktop display. Yang et al. [14] designed a virtual reality learning environment (VRLE) to help students understand how to disassemble or assemble bogie. The subjects were randomly divided into the experimental and control groups, and each included 31 boys and 9 girls majoring in urban rail vehicle engineering. Virtual reality was found to play a positive role in the acquisition of operation skills of students, and teaching helps to reduce their cognitive loads in the experiment. Lamb et al. [15] demonstrated

that the writing ability can be significantly improved if students know virtual marine environments before writing. Alhalabi [16] evaluated the influence of virtual reality system and found significant improved performance among 48 students in Colleges of Engineering. Hamilton et al. [17] demonstrated that the use of IVR in education has considerable advantages. Shim et al. [18] investigated the influence of design education based on virtual reality coding on the scientific ability of 310 students and had the greatest influence on overall educational satisfaction in South Korea. Degli Innocenti et al. [19] demonstrated that the collaborative use of mobile virtual reality technology and traditional teaching methods can improve the music learning experience in primary schools, including active listening, attention, and time. Huang et al. [20] found that virtual reality is more immersive and attractive through space existence mechanisms. Ammanuel et al. [21] reported that VR is a powerful tool increasingly used by the medical community in recent years. In the experimental teaching of anatomy, 3D virtual space teaching experiments can allow medical students to more directly perceive the teaching content and improve their operation skills. Lamb et al. [22] demonstrated that actual operating conditions, severe educational games, and virtual reality conditions are equivalent in terms of learning outcomes and cognitive process. Nissim et al. [23] found that teachers using VRLE together can help them improve their sense of self-efficacy and make them more innovative and creative. Virtual reality challenges students with active teaching and learning and enables them and teachers to become active participants in creation and innovation. From the existing literatures that immersive virtual reality has fully penetrated the education industry and caused a significant impact on the skills transfer of learners. However, the skills transfer is easy to be indirectly affected by various factors, such as sense of presence and learning motivation. The degree of influence on learning performance also presents a certain difference. Moreover, as a key factor affecting learning performance, engagement can also easily affect the process and result of skills transfer of learners. According to the consistent trend in the existing research, this study follows the two issues by means of T-value test, variance test, covariance analysis, and moderating effect analysis: (1) Whether immersive virtual reality teaching methods can significantly improve skills transfer of learners; and (2) As regulated variable, whether learning engagement moderates the effect of immersive virtual reality teaching on skills transfer.

3 Research design

Considering the applicability of immersive virtual reality teaching technology, and the existence of most research literature, this study still plans to take the English translation course for industrial design major as research content. A grouping experiment is designed, wherein the experimental group adopts an immersive virtual reality teaching method while the control group uses the traditional teaching mode. Comparative analysis of differences between the two groups can allow for the full evaluation of the effect of experimental teaching supported by immersive virtual reality technology on the skills transfer performance of English learners.

3.1 Study objects

PA total of 30 undergraduates majoring in design science was selected from a provincial university in Dalian, Liaoning Province, and provided with corresponding technical support for the investigation and research. Among the sample, 14 are boys and 16 are girls. As for their majors, four were environmental design, 12 were product design, six in digital media art, and 8 in industrial art, they had learned professional English translation courses. The group was divided in two by randomly assigning 15 to the experimental group (accept immersive virtual experimental learning) and the other half to the control group (accept non-immersive virtual experimental learning).

3.2 Study situations and tools

Knowledge reading materials were provided to ensure that all research subjects can fully and scientifically understand the basic concept of professional English translation courses and master basic operations of corresponding equipment in the immersive virtual reality teaching experiment. The main equipment required for the experiment was the virtual experiment software and its supporting hardware.

3.3 Data collection

The questionnaire included three parts. The first part included the basic information, such as the subjects' age, major, and familiarity with immersive virtual reality teaching mode. The second part was about learning engagement, adapted from Reeve et al. [24] to redesign four aspects. The third part was the test for skills transferability from virtual to real base on the evaluation score given by teachers (percent system) after learners completed the virtual experiment. Given the main goal of this experiment was to skillfully complete an application-oriented task; almost all subjects were successful without any time limit.

4 Results

4.1 Pre- and post-test scores of different majors

Table 1 shows that the pre-test scores of students majoring in Environmental Design, Product Design, Digital Media Art, and Industrial Art were approximately 70 points, but the post-test scores increased by approximately 15%. These results indicate that students in the university had stronger learning enthusiasm, and can obtain higher scores through learning.

Table 1. Subtotals and analysis results: basic indicators (mean value)

Item	Major				Total
	Environmental design	***Product design***	***Digital media art***	***Industrial art***	
Pre-test score	72	70	68.833	72.5	70.7
Post-test score	83.75	82.333	81.667	85.25	83.167

4.2 Differences of training methods between pre- and post-test scores

Table 2 shows no significant difference in all pre-test scores of students who received different training methods (p>0.05), but a significant difference in all post-test scores of students who received different training methods (p<0.05). Specific analysis shows that the training method has a significant level of 0.01 on the post-test scores (F=12.739, p=0.001), and the mean value of 1.0 (80.33) is significantly lower than the mean value of 2.0 (86.00). In conclusion, different training methods do not affect pre-test scores but significantly influenced the post-test scores.

Table 2. Variance test results

	Training methods (mean value ± standard deviation)		***F***	***p***
	Control group (n=15)	***Experimental group (n=15)***		
Pre-test scores	69.93±5.44	71.47±4.55	0.701	0.41
Post-test scores	80.33±4.50	86.00±4.19	12.739	0.001**

*p<0.05, **p<0.01

4.3 Immersive virtual experiments are more helpful to cultivate the ability of skills transfer

Before analyzing the moderating effect, this study verifies whether immersive virtual experiment is more helpful to cultivate the skills transferability of learners. The covariance analysis method was used to control for the possible influence of basic level of translation of learners on analysis results and explore the differences in the skills transferability of both groups. Covariance analysis is a common statistical method for testing significant differences between two groups and control for the influence of covariance on results based on variance analysis. Covariates refer to variables that cannot be controlled artificially and may influence the dependent variable, namely, the basic level of learners in this study. "Training method" is the independent variable, "post-test score" is the dependent variable, and "pre-test score" is the covariate. The covariance analysis is carried out in SPSS 22.0. Table 3 shows the results.

Table 3. Covariance analysis result

Source of variance	**Sum of squares**	***df***	**Mean square**	***F***	***p***
Intercept	187.753	1	187.753	22.695	0.000**
Training method	158.638	1	158.638	19.176	0.000**
Pre-test score	305.968	1	305.968	36.985	0.000**
Residual	223.365	27	8.273	-	-
R^2: 0.710					

*p<0.05, **p<0.01

Table 3 shows the difference between training method (immersive virtual or traditional teaching method) and pre-test score, which serves as covariates in the covariance analysis to prevent other factors from interfering with the model. The post-test scores of students in the experimental group (86.00±4.19) were higher than those in the control group (80.33±4.50), indicating a significant difference in the transfer of skills level. These results indicate that the skills transfer level of learners in the immersive virtual experiment is significantly higher than those in non-immersive virtual experiments. Thus, immersive virtual experiment is more helpful to cultivate the ability of skills transfer. The main reason is that IVR technology can enhance the learning experience and gain, which can help learners to transform more complex higher-order thinking into specific working ability, and then improve their ability to solve practical problems.

4.4 Analysis of moderating effect

Table 4 shows that the moderating effect is divided into three models. Model 1 includes independent variable (training mode). Model 2 includes the moderating variable (learning engagement) based on Model 1, and Model 3 includes interaction items (product term of independent variable and moderating variable) based on Model 2. Model 1 aims to explore the influence of the training mode on the post-test score without considering the interference of moderating variable (learning engagement). The results show that the independent variable (training method) is significant (t=3.569, p=0.001<0.05), which means that training methods have a considerable effect on post-test scores. The moderating effects can be examined in two ways; first, the significance of the change in F value from Model 2 to Model 3, and second is the significance of interaction terms in Model 3. The second method is used for analysis in this study. Table 4 also shows a significance in interaction terms between the training method and learning engagement (t=-2.212, p=0.036<0.05), which means that the moderating variable (learning engagement) has a significant difference in the impact of training methods on post-test scores at different levels. Thus, learning engagement has a clear moderating effect, which can regulate the influence of immersive virtual experiment on the ability of skills transfer. The learners with less learning engagement in the control group show lower abilities of skill transfer than those with more learning engagement. Thus, learners with different levels of learning engagement show varying behavior patterns. The more the learning engagement is, the more interaction behaviors of the learners. This finding fully explains the reason for the moderating effect due to different learning styles. Given that immersive virtual experimental teaching requires learners to have full and long-time space imagination, more learning engagement can meet their necessary learning time and energy input, such that they can obtain more direct and apparent knowledge. The results of extensive literature also explain that learning engagement is an important variable affecting the level of learning performance; the more the learning engagement of learners, the more apparent the overall learning effect.

Table 4. Moderating effect of learning engagement

	Model 1	**Model 2**	**Model 3**
Constant	83.167** (104.767)	83.167** (104.065)	86.843** (47.654)
Training method	5.667** (3.569)	2.867 (0.738)	2.131 (0.585)
Learning engagement	-	1.500 (0.791)	1.894 (1.063)
Training method * learning engagement	-	-	-7.879*(-2.212)
R^2	0.313	0.328	0.435
Adjust R^2	0.288	0.279	0.369
F	F (1,28)=12.739, p=0.001	F (2,27)=6.598, p=0.005	F (3,26)=6.664, p=0.002
$\triangle R^2$	0.313	0.016	0.106
$\triangle F$	F (1,28)=12.739, p=0.001	F (1,27)=0.626, p=0.436	F (1,26)=4.893, p=0.036
Dependent variable: post-test score			

*p < 0.05, **p<0.01, t value in brackets

5 Managerial implications

5.1 Relying on immersive virtual reality technology, this study scientifically and systematically reconstructs the teaching activities

Immersive virtual reality technology can provide an immersive teaching environment for different educational institutions, and enable learners to be more imaginative and interactive. In this study, the experimental results also proved that, compared with the traditional teaching mode, immersive virtual teaching can more efficiently promote the skills transfer of learners and comprehensively increase the mastery levels. At present, countries around the world have increasingly carried out immersive virtual reality teaching into the emerging educational mode, which is more helpful for the physical and mental development of learners. In vigorously introducing immersive virtual reality technology, more attention is paid on the development of supporting teaching resources, and highly restores real work scenarios to virtual reality. Meanwhile, combined with the cognitive differences of learners, this study gives full play to the advantages of immersive virtual reality technology to support the exploratory teaching mode by using equipment based on "learner-oriented and teacher-assisted". In the process of immersive virtual reality teaching, the importance in not only simply relying on the technology itself but also attaching importance to the emotional interaction between teachers and learners to promote the learning engagement and cognitive adjustment of learners.

5.2 Explore personalized teaching design and expand immersive virtual experimental teaching

The traditional education mode focuses on the teaching behavior of teachers, but the immersive virtual reality teaching mode pays more attention to the student-centered application, where each learner adopts a richer and more personalized learning mode. Immersive virtual reality teaching is characterized of strong interactive teaching, rich resources, and dynamic teaching methods such that learners can gain the main control position and decision-making power during learning. At present, immersive virtual reality teaching experiment software places greater importance on the development and application of common teaching characteristics and does not realize the personalized needs of learners. In this paper, the research results also fully show that the immersive virtual reality teaching experiment must also pay attention to the influence of learning engagement and other factors, and consider the personality characteristics of learners to comprehensively improve their skills transfer level. In particular, to scientifically evaluate the various monitoring data in the process of immersive virtual teaching along with constant embedding of artificial intelligence and other emerging technologies is necessary. How to use monitoring data to analyze learning habits and behavior tendency of learners can be considered to develop more accurate and personalized learning scenarios. The use of different teaching environments and adjustments of various sensory stimulations in immersive reality teaching environments can reduce the invalid behavior of learners, extend the learning engagement time of learners and improve the quality.

5.3 Choose content and method of simulation experiment, promote deep cognitive learning processing

The purpose of immersive experimental teaching is not to achieve excessive sensory stimulation, but to promote learning performance by constructing a good educational system. Therefore, with respect to the content of immersive virtual reality teaching, choosing representative knowledge that can be easily combined with new technologies is necessary to enable concentration on learning. Increasing the cognitive load is easy because of the long-term use of media environment, and thus the immersive virtual experiment should develop more scenarios that are beneficial to cognition and selectively carry out simulation experiments. Therefore, the key future direction needs to be considered, such as on how to research and develop learning resources of the translation course with high degree of simulation, especially integrating the latest teaching content into immersive virtual reality teaching. By acquiring the data from the learning process, the learning behavior can be analyzed and evaluated such that learners can achieve greater breakthroughs in higher-order thinking mode.

6 Conclusion

Big data, 5G technology, and other emerging technologies have gradually realized the informatization in the field of education, and thus teachers and students gradually

accept the virtual reality teaching mode. This immersive virtual teaching has achieved rapid development in the world with its advantages of high simulation, friendly interaction, and comprehensive real perception. In addition, this mode also brings opportunities for how to realize updates in teaching methods and concepts in the field of education. In analyzing the skills transfer in immersive virtual reality teaching environment and using covariance analysis method, this study determines the difference of skills transfer of learners and reveals the moderating effect of learning engagement. The results show that training method has a significant difference in post-test scores, and immersive virtual experiment can better cultivate the skills transferability compared with the traditional teaching mode. Learning engagement plays a distinct moderating role in the effect of immersive virtual reality on the skills transfer of learners, and shows the need for intensive study on the multi-subject and multi-level comprehensive evaluation of the effect of experimental teaching.

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8 References

[1] Psotka, J. (1995). Immersive training systems: Virtual reality and education and training. Instructional Science, 23(5), 405-431. https://doi.org/10.1007/BF00896880

[2] Bossard, C., Kermarrec, G., Buche, C., Tisseau, J. (2008). Transfer of learning in virtual environments: a new challenge?. Virtual Reality, 12(3), 151-161. https://doi.org/10.1007/s10055-008-0093-y

[3] Ganier, F., Hoareau, C., Tisseau, J. (2014). Evaluation of procedural learning transfer from a virtual environment to a real situation: a case study on tank maintenance training. Ergonomics, 57(6), 828-843. https://doi.org/10.1080/00140139.2014.899628

[4] Dolgunsöz, E., Yildirim, G., Yildirim, S. (2018). The effect of virtual reality on EFL writing performance. Journal of Language and Linguistic Studies, 14(1), 278-292.

[5] Lin, M. T. Y., Wang, J. S., Kuo, H. M., Luo, Y. (2017). A study on the effect of virtual reality 3D exploratory education on students' creativity and leadership. Eurasia Journal of Mathematics, Science and Technology Education, 13(7), 3151-3161. https://doi.org/10.12973/eurasia.2017.00709a

[6] Samadbeik, M., Yaaghobi, D., Bastani, P., Abhari, S., Rezaee, R., Garavand, A. (2018). The applications of virtual reality technology in medical groups teaching. Journal of Advances in Medical Education & Professionalism, 6(3), 123-129.

[7] Chae, C. J., Lee, J. W., Jung, J. K., Ahn, Y. J. (2018). Effect of Virtual Reality Training for the Enclosed Space Entry. Journal of the Korean Society of Marine Environment & Safety, 24(2), 232-237. https://doi.org/10.7837/kosomes.2018.24.2.232

[8] Kim, K. G., Oertel, C., Dobricki, M., Olsen, J. K., Coppi, A. E., Cattaneo, A., Dillenbourg, P. (2020). Using immersive virtual reality to support designing skills in vocational education. British Journal of Educational Technology, 51(6), 2199-2213. https://doi.org/10.1111/bjet.13026

[9] Schofield, D. (2012). Mass effect: A chemical engineering education application of virtual reality simulator technology. Journal of Online Learning and Teaching, 8(1), 63-78.

[10] Soto, J. B., Ocampo, D. T., Colon, L. B., & Oropesa, A. V. (2020). Perceptions of ImmerseMe virtual reality platform to improve English communicative skills in higher education. International Journal of Interactive Mobile Technologies, 14(7), 4-19. https://doi.org/10.3991/ijim.v14i07.12181

[11] Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. Computers & Education, 70, 29-40. https://doi.org/10.1016/j.compedu.2013.07.033

[12] Meyer, O. A., Omdahl, M. K., Makransky, G. (2019). Investigating the effect of pre-training when learning through immersive virtual reality and video: A media and methods experiment. Computers & Education, 140, 103603. https://doi.org/10.1016/j.compedu.2019.103603

[13] Rau, P. L. P., Zheng, J., Guo, Z., Li, J. (2018). Speed reading on virtual reality and augmented reality. Computers & Education, 125, 240-245. https://doi.org/10.1016/j.compedu.2018.06.016

[14] Yang, J., Liu, F., Wang, J., Kou, Z., Zhu, A., Yao, D. (2021). Effect of virtual reality technology on the teaching of urban railway vehicle engineering. Computer Applications in Engineering Education, 29(5), 1163-1175. https://doi.org/10.1002/cae.22371

[15] Lamb, R. L., & Etopio, E. (2019). Virtual reality simulations and writing: A neuroimaging study in science education. Journal of Science Education and Technology, 28(5), 542-552.

[16] Alhalabi, W. (2016). Virtual reality systems enhance students' achievements in engineering education. Behaviour & Information Technology, 35(11), 919-925. https://doi.org/10.1007/s10956-019-09785-9

[17] Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. Journal of Computers in Education, 8(1), 1-32. https://doi.org/10.1007/s40692-020-00169-2

[18] Shim, H., Lee, H. (2021). The effect of design education using virtual reality-based coding on student competence and educational satisfaction. Education and Information Technologies. https://doi.org/10.1007/s10639-021-10730-w

[19] Degli Innocenti, E., Geronazzo, M., Vescovi, D., Nordahl, R., Serafin, S., Ludovico, L. A., Avanzini, F. (2019). Mobile virtual reality for musical genre learning in primary education. Computers & Education, 139, 102-117. https://doi.org/10.1016/j.compedu.2019.04.010

[20] Huang, K. T., Ball, C., Francis, J., Ratan, R., Boumis, J., Fordham, J. (2019). Augmented versus virtual reality in education: an exploratory study examining science knowledge retention when using augmented reality/virtual reality mobile applications. Cyberpsychology, Behavior, and Social Networking, 22(2), 105-110. https://doi.org/10.1089/cyber.2018.0150

[21] Ammanuel, S., Brown, I., Uribe, J., & Rehani, B. (2019). Creating 3D models from radiologic images for virtual reality medical education modules. Journal of medical systems, 43(6), 1-3. https://doi.org/10.1007/s10916-019-1308-3

[22] Lamb, R., Antonenko, P., Etopio, E., & Seccia, A. (2018). Comparison of virtual reality and hands on activities in science education via functional near infrared spectroscopy. Computers & Education, 124, 14-26. https://doi.org/10.1016/j.compedu.2018.05.014

[23] Nissim, Y., Weissblueth, E. (2017). Virtual reality (VR) as a source for self-efficacy in teacher training. International Education Studies, 10(8), 52-59. https://doi.org/10.5539/ies.v10n8p52

[24] Reeve, J., Tseng, C. M. (2011). Agency as a fourth aspect of students' engagement during learning activities. Contemporary Educational Psychology, 36(4), 257-267. https://doi.org/10.1016/j.cedpsych.2011.05.002

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