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PAPER

Assessment of Biology Teacher Candidates' Attitudes and Competencies Toward Virtual Reality Applications

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ABSTRACT

The purpose of this research is to evaluate the attitudes and competencies of biology teacher candidates regarding virtual reality applications based on scientific and methodological developments for the improvement of the visualization system in biology. In this study, the survey model, which is one of the quantitative research methods, was used. The sample group of the research consists of 244 biology teacher candidates studying at various universities in Kazakhstan in the 2022–2023 academic year. Research data were collected with a virtual reality attitude and competence scale developed by the researchers. After exploratory and confirmatory factor analyses and construct validity studies were carried out, reliability analyses of the scale were made to get the final form of the scale, and Cronbach's alpha reliability coefficient was calculated. As a result of the research, it was determined that the attitudes of pre-service biology teachers towards virtual reality were high and their competencies related to virtual reality were low. This suggests that biology teacher candidates have a medium level of attitude and competence in the virtual reality attitude and competence scale. In line with the findings obtained from the research, suggestions were made to improve the virtual reality attitudes and competencies of teacher candidates.

KEYWORDS

art technology, competence development, student opinions

1 INTRODUCTION

Information and communication technologies cover all technologies that enable information to be obtained and enable and facilitate communication between people, or between people and electronic systems, or between electronic systems [1,2]. In addition, changes and developments in information and technology take place in all areas of our lives, and therefore, the globalization of information is ensured by the changes in communication tools [3,4]. With the technologies that have become a part of life, using virtual objects, being able to present work with realistic objects, and

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using the virtual environment and the object integrated with real images increase the interest in technology that can be used easily among users [5–7]. Virtual reality technology is one of these technologies. It is a simulation model that feels real and provides the opportunity to interact with a real environment created by computers [8,9].

1.1 Theoretical and conceptual framework

Augmented reality technologies emerge when a feeling of virtual reality is created without being separated from the real environment [10]. Augmented reality is a technology in which objects from the real environment and virtual objects are combined and simultaneous interaction is provided with virtual objects integrated with the real image [11]. Virtual reality is defined as the 3D simulation of a real or imaginary system. Users of such a system can generally use virtual objects in the simulated environment by processing them in real time [12].

It is possible to come across different definitions of the concept of virtual reality in the literature. Virtual reality is a technology that provides a 2D or 3D situation where users can interact with each other or with other applications [13]. It has been determined that the use of augmented reality applications in education, as a result of the concretization of abstract concepts, increases the understanding of concepts and processes; increases the focus time of the students and affects their academic success positively; and provides benefits in subjects such as paying attention to the lesson, increasing motivation, and enjoying the process [14].

With the use of teaching materials created with virtual reality technologies, it is expected that the level of learning and its impact on students will increase as more sense organs are engaged [15–17]. The areas where virtual reality technology are used are increasing day by day. The main idea underlying the reason for its use in many areas is the same: to train the user in the area where it is used [18].

Thanks to virtual reality, it is possible to teach someone the details of work and to offer the person the opportunity for self-development by experiencing the work [19]. When virtual reality is used in the field of education, it exhibits a student-centered approach [20]. A student-controlled educational environment becomes more interactive than a traditional classroom setting [21]. Virtual reality technologies provide opportunities to streamline teaching and learning and optimize learning [22–25]. They guides the student with applications created with technology and provide a basis for permanent learning, especially with the ability to practice in subjects that have been presented or explained theoretically. This shows that virtual reality supports the utilitarian understanding of education [26].

Virtual reality technology is also making progress in developmental studies on psychological and pedagogical principles in promoting learning [27]. With the development of technology, virtual reality, which is used increasingly in educational environments, is also used to establish a solid foundation for evidence-based education and learning [28]. Thanks to the experience of the educational environment, positive results are observed in the acquisition of knowledge and skills. It is also possible to evaluate the effect on students' attitudes toward virtual reality technology [29].

1.2 Related research

Chiu et al. [30] investigated how to support students to explain microscopic events at the molecular level by creating augmented virtual science laboratories

and combining physical and virtual experiments in science lessons. In the laboratory, which was arranged for research purposes, students studied the movements of gas molecules. As a result of the research, it was concluded that there was an increase in the interest and success of the students in the science lesson, thanks to the application. Zhou et al. [31] designed a microscope that can be used in an environment where experimental experiences are carried out with virtual reality technologies, and they stated that the tool developed contributes to the development of students' learning outcomes, their affective development, and their motivation for their learning.

With virtual reality technology, Paxinou et al. [32] created virtual biology laboratories with microscopes and examined the effect of a virtual microscope. As a result of the research, they revealed that the environment they developed was supportive of understanding the details and had promising potential. Papanastasiou et al. [33] aimed to present state-of-the-art approaches and examples of augmented reality and virtual reality systems, practices, and experiences that improve the real-world generalization of students' learning and skills. The results showed that augmented reality and virtual reality environments improve learning outcomes and offer numerous advantages of investing time and financial resources in higher education environments.

Stavroulia et al. [34] examined the effects of using a special virtual reality application for teachers to help control bullying in educational environments. Teachers stated that a similar environment of applications developed with virtual reality could be useful in recognizing school-bullying incidents and in education. In a study conducted by Herga et al. [35], it was concluded that students who use virtual labs develop their spatial visualization skills better than students who do not use virtual labs.

1.3 Purpose of the research

The purpose of this research was to evaluate the attitudes and competencies of biology teacher candidates regarding virtual reality applications based on scientific and methodological developments for the improvement of the visual system in biology. For this purpose, the following research questions were developed.

1. At what level are biology teacher candidates' attitudes and competencies, regarding virtual reality applications?
2. Do the attitudes and competencies of biology teacher candidates towards virtual reality applications differ according to gender?
3. Do the attitudes and competencies of biology teacher candidates towards virtual reality applications differ according to the class they are studying?

2 METHODOLOGY

2.1 Research method

In this study, the survey model, which is one of the quantitative research methods, was used. As a descriptive research method, it examines the opinions of the participants on a subject or their characteristics such as skills, abilities, interests, and attitudes. Generally, larger samples are needed than in other studies. The most

ideal way to reach large samples is through survey studies, where more quantitative data can be collected. Quantitative research aims to obtain objective and reliable results. Generalizations are made with the statistical results of quantitative research expressed using numerical data [36].

2.2 Participants

The sample group of the research consists of 244 biology teacher candidates studying at various universities in Kazakhstan in the 2022–2023 academic year. Demographic characteristics of biology teacher candidates participating in the study are given in Table 1.

Table 1. Demographic characteristics of teacher candidates

	N	%
Gender		
Female	115	47.1
Male	129	52.9
The grade level at which they were studying		
• First grade	63	25.8
• Second grade	72	29.5
• Third grade	59	24.2
• Fourth grade	50	20.5
Total	244	100

In Table 1, the gender and class distributions of the biology teacher candidates participating in the research are given. 47.1% of teacher candidates were female and 52.9% were male. 25.8% of the pre-service teacher's were studying in the first grade, 29.5% in the second grade, 24.2% in the third grade, and 20.5% in the fourth grade.

2.3 Data collection tools

Research data were collected with the virtual reality attitude and competence scale developed by the researchers. The first stage of the scale development study was the literature review. During the literature review, studies on the use of virtual reality technology in education were discussed, read, and examined. An item pool was also created by looking at what should be considered for item writing. Question items that had the same meaning or that described the same situation in the answer were corrected. Care was taken to ensure that the scale items were simple and understandable as well as grammatical. As a result of all this screening, an pool of 31 items was created. Necessary corrections were made in the content of the item pool prepared for the creation of the scale, after obtaining feedback obtained from interviews with three experts. After these corrections, a 22-item scale form was finalized. In line with expert opinions, the content and face validity of the scale form were evaluated. The research scale to be applied to the pilot study group was arranged as a two-page form. The questionnaire, which contained brief information

about the research, started with demographic questions about the grade levels and genders of the study group. Two hundred and eighteen (218) biology teacher candidates participated in the pilot application of the research.

Exploratory factor analysis was applied to the data set obtained after the pilot application. Kaiser Meyer, in the first step of the exploratory factor analysis study, was applied to the scale to determine whether the data obtained from the application organized for the scale was suitable for factor analysis. It was tested by looking at the Olkin and Barlett tests. The Kaiser Meyer Olkin value was 0.922 and the Bartlett Sphericity Test value was 3,944.132, which is significant at the 0.001 level, and the data obtained from the application show that it was suitable for factor analysis. Exploratory factor analysis was done with the Statistical Package for the Social Sciences (SPSS) 25.0 program. In the exploratory factor analysis performed, it is seen that 22 items included in the analysis in line with the data in the data set were grouped under two factors because their eigenvalues were greater than 1. It was determined that the variance value explained by these two factors regarding the scale was 82.682%. The first factor was named "Attitude towards virtual reality" and the second factor was named "Competence related to virtual reality." The load values of the items in the first factor varied between 0.813 and 0.877. The load values of the items in the second factor varied between 0.723 and 0.799. The construct validity of the 2-factor model obtained as a result of exploratory factor analysis, confirmatory factor analysis, and testing was performed using the SPSS AMOS program. In the confirmatory factor analysis, the goodness-of-fit index was examined. For model fit, chi-square/degree of freedom (χ^2/df), Non-Normed Fit Index (NNFI), and Root mean square Error of Approximation (RMSEA) values were determined as criteria. According to the results of the analysis, the fit indices are χ^2 / df = 2.13 (p = 0.000), NNFI = 0.89, and RMSEA = 0.070. less than 5 for χ^2/ df; above 0.80 for NNFI and below 0.080 for RMSEA is recommended. Accordingly, the 2-factor model was compatible with the data with acceptable values.

With this result, it is possible to say that the 22-item and 2-factor structure of the attitude and competence scale was confirmed according to the compliance statistics. After exploratory and confirmatory factor analyses and construct validity studies were carried out, reliability analyses of the scale were made to get the final form of the scale, and Cronbach's alpha reliability coefficient was calculated. The Cronbach's alpha coefficient for the first factor was 0.82, for the second factor, it was 0.85, and for the overall scale, it was 0.82. These values obtained as a result of the analysis showed that a sufficiently high percentage of reliability was achieved. The virtual reality attitude and proficiency scale items that were ready to collect research data are given in Table 2.

Table 2. Virtual reality attitude and competence scale

Factor 1: Attitude Toward Virtual Reality	
1	I can better give myself to the lesson when virtual reality applications are used.
2	Virtual reality apps make it easier for me to learn.
3	I would like virtual reality applications to be used in all courses in the future.
4	Virtual reality provides interactive learning.
5	Thanks to virtual reality, my attention to the lesson increased.
6	Virtual reality in the lesson increases my motivation towards the lesson.
7	Thanks to virtual reality, I take a more active role in the lessons.

(Continued)

Table 2. Virtual reality attitude and competence scale *(Continued)*

Factor 1: Attitude Toward Virtual Reality	
8	Virtual reality provides effective learning environments for the course.
9	Virtual reality facilitates experiential learning.
10	I focus better on the lesson when virtual reality applications are used.
11	Virtual reality offers effective environments that increase creative thinking.
12	Thanks to virtual reality, I can interact realistically.
13	Virtual reality gives me a sense of reality.
Factor 2: Competence in Virtual Reality	
14	My knowledge of virtual reality is sufficient.
15	I can use virtual reality applications while teaching.
16	I can combine my field knowledge with virtual reality.
17	I can combine my pedagogical knowledge with virtual reality.
18	I can increase student success by using virtual reality applications.
19	I can increase student motivation by using virtual reality applications.
20	I can easily teach any subject in my field with virtual reality applications.
21	I can solve the problems to be encountered in the classroom environment related to virtual reality.
22	With virtual reality applications, I can enable students to take a more active role in the lesson.

The virtual reality attitude and competence scale prepared to collect research data is given in Table 2. The scale was prepared using a 5-point Likert scale: "Strongly agree" was determined as 5 points, "Agree" 4 points, "Partly agree" 3 points, "Disagree" 2 points, and "Strongly disagree" 1 point. Since the scores on the scale were between 1.00 and 5.00, it was accepted that the student's level of participation in the proposition was high as the scores get closer to 5, and low as they get closer to 1.00. The item score ranges of the scale were evaluated as "strongly agree" 5.00–4.20, "agree" 4.19–3.40, "partially agree" 3.39–2.60, "disagree" 2.59–1.80, and "strongly disagree" 1.79–1.00.

2.4 Data collection process

The research data were collected at appropriate time intervals by obtaining the necessary permissions from the biology teaching departments of the universities where the research was conducted. The application time of the virtual reality attitude and proficiency scale was between 15 and 20 minutes. The applications were carried out in groups. It took about 3 weeks to complete the applications with all biology teacher candidates participating in the research group.

2.5 Compliance with ethics

During the research process, journal writing rules, publication principles, research and publication ethics rules, and journal ethics rules were followed.

Responsibility for any violations that might arise regarding the research belongs to the authors. After the preparation of the data collection tool, necessary permissions were obtained from the universities where the research would be conducted to research the study group. It was announced that the study group would be informed about participation on a completely voluntary basis by giving information before the research. Verbal consent was obtained from the students who agreed to participate in the study before the data collection tool was applied.

2.6 Data analysis

The SPSS 25.0 program was used in the analysis of the data. Before deciding which analyses to be performed, a test of normality was performed. After this analysis, it was determined that the data were normally distributed because the Kolmogorov–Smirnov value ($p > 0.05$) was appropriate. It was decided to perform parametric analyses because the data conformed to the normal distribution. An independent groups t-test and one-way analysis of variance (ANOVA) were used to analyze the data.

3 RESULTS

In Table 3, the weighted averages and standard deviations of the biology teacher candidates participating in the research regarding the overall virtual reality attitude and competence scale and its sub-dimensions are given.

Table 3. Weighted average and standard deviations of virtual reality attitude and proficiency scale

	X	SS
Attitude toward virtual reality	3.62	0.794
Proficiency in virtual reality	2.31	0.837
Virtual reality attitude and competence scale	3.08	0.665

Table 3 shows the attitude sub-dimension related to virtual reality (X = 3.62, SS = 0.794), the competence sub-dimension related to virtual reality (X = 2.31, SS = 0.837), and the overall virtual necessity attitude and competence scale (X = 3.08, SS = 0.665) weighted mean and standard deviations are given. These data show that pre-service biology teachers had high attitudes toward virtual reality but low proficiency in virtual reality. In addition, it is possible to say that biology teacher candidates had a moderate level of attitude and competence in the virtual reality attitude and competence scale.

The t-test results of independent variables according to the gender variable of biology teacher candidates participating in the research are given in Table 4.

Table 4. Independent variable t-test results

Gender	N	X	SS	F	p
Female	115	3.06	0.699	6.725	0.210
Male	129	3.10	0.628		

In Table 4, virtual reality attitudes and competencies of biology teacher candidates participating in the research were evaluated according to the gender variable. As a result of the independent variables t-test, no significant difference was found in the virtual reality attitudes and competencies of the biology teacher candidates according to the gender variable ($F = 6.725$, $p > 0.05$).

In Table 5, one-way ANOVA results according to the class variable of the biology teacher candidates participating in the research are given.

Table 5. One-way ANOVA results

Grade	X	SS	F	p	
First grade	63	3.00	0.877	16.392	0.000
Second grade	72	3.01	0.860		
Third grade	59	3.03	0.829		
Fourth grade	50	3.31	0.651		

In Table 5, virtual reality attitudes and competencies of the biology teacher candidates participating in the research were evaluated according to the class variable. As a result of the one-way ANOVA, it was determined that the virtual reality attitudes and competencies of the biology teacher candidates showed a significant difference according to the class variable ($F = 16.392$, $p < 0.5$). It was determined that the significant difference in the virtual reality attitudes and competencies of the biology teacher candidates according to the class variable they studied favored the fourth-grade teacher candidates.

4 DISCUSSION

The findings obtained from the research reveal that the attitudes of biology teacher candidates about virtual reality are high, but their competencies about virtual reality are low. Biology teacher candidates have a medium level of attitude and competence in the virtual reality attitude and competence scale. In their study, Karagozlu [37] determined the attitudes of students toward augmented reality applications in science lessons. The research revealed that students are satisfied with virtual reality applications, find them interesting and easy to use, and want to use them in the future.

It was determined that there was no significant difference by gender in the virtual reality attitudes and competencies of the biology teacher candidates participating in the research. Antonietti et al. [38] evaluated virtual reality applications in education. Their research revealed that there was no difference in terms of gender in virtual reality applications. Similarly, Yavuz and Uslu [39] found no significant difference by gender in the views of teacher candidates on the use of virtual reality in education.

There is a significant difference when the virtual reality attitudes and competencies of biology teacher candidates are evaluated according to the class variable they are studying. The obtained results reveal that the significant difference is in favor of the fourth-grade biology teacher candidates. Yavuz and Uslu [39], unlike the results of this study, stated that the class variable they studied did not make a significant difference in their research in which the views of pre-service teachers about the use of virtual reality technology in education were evaluated.

5 CONCLUSIONS

In recent years, there has been rapid development in information and communication technologies. This development appears in every aspect of our lives, and education is not indifferent to this development. With technology integrated into education, new concepts emerge in the field of education. One of the emerging new concepts is virtual reality. This research was aimed to evaluate the attitudes and competencies of biology teacher candidates regarding virtual reality applications based on scientific and methodological developments for the improvement of the visual system in biology.

As a result of the research, it was determined that the attitudes of pre-service biology teachers towards virtual reality were high and their competencies related to virtual reality were low. It is possible to say that biology teacher candidates have a medium level of attitude and competence in the virtual reality attitude and competence scale. While no significant difference was determined in the virtual reality attitudes and competencies of the biology teacher candidates participating in the research according to the gender variable, it was determined that there was a significant difference in favor of the biology teacher candidates studying in the fourth grade, according to the class variable.

In line with the results obtained from the research, the following suggestions are proposed:

1. Due to the high virtual reality attitudes of biology teacher candidates, it has become necessary to give more places to teacher-training programs given in universities.
2. Due to the low virtual reality proficiency of biology teacher candidates, care should be taken to ensure that the courses are added to teacher-training programs at universities meet teacher qualification.
3. This research, which was carried out with pre-service biology teachers, should be repeated with pre-service teachers studying in different departments in education faculties to determine how their virtual reality attitudes and competencies can contribute to the field.

6 REFERENCES

[1] Cetin, S. General trends in master and doctorate thesis in the area of computers education and instructional technologies in Turkey. International Journal of Innovation Research in Education, 2015, 2(2), 55–67. https://doi.org/10.18844/ijire.v2i2.352

[2] Rafalow, M. H., Puckett, C. Sorting machines: Digital technology and categorical inequality in education. Educational Researcher, 2022, 51(4), 274–278. https://doi.org/10.3102/0013189X211070812

[3] Ongoz, S., Aksoy, D. A. What do gifted students expect from the information technology course? International Journal of Special Education and Information Technologies, 2015, 1(1), 34–47. https://doi.org/10.18844/jeset.v1i1.3549

[4] Zhang, K. Determining the influence factors affecting the digital competencies of college students in blended teaching. Contemporary Educational Researches Journal, 2021, 11(4), 210–224. https://doi.org/10.18844/cerj.v11i4.5974

[5] Uzunboylu, H., Yıldız, E. Augmented reality research and applications in education. New Trends and Issues Proceedings on Humanities and Social Sciences, 2016, 2(11), 238–243. http://www.prosoc.eu/; https://doi.org/10.18844/prosoc.v2i11.1927
[6] Wörner, S., Kuhn, J., Scheiter, K. The best of two worlds: A systematic review on combining real and virtual experiments in science education. Review of Educational Research, 2022, 92(6), 911–952. https://doi.org/10.3102/00346543221079417
[7] Glavas, C., Schuster, L. Design principles for electronic work integrated learning (eWIL). The Internet and Higher Education, 2020, 47, 100760. https://doi.org/10.1016/j.iheduc.2020.100760
[8] Fetaji, B., Fetaji, M., Asilkan, O., Ebibi, M. Examining the role of virtual reality and augmented reality technologies in education. New Trends and Issues Proceedings on Humanities and Social Sciences, 2020, 7(3), 160–168. https://doi.org/10.18844/prosoc.v7i3.5247
[9] Casselman, M. D., Eichler, J. F., Atit, K. Advancing multimedia learning for science: Comparing the effect of virtual versus physical models on student learning about stereochemistry. Science Education, 2021, 105(6), 1285–1314. https://doi.org/10.1002/sce.21675
[10] Kukeneh, S. S., Shahbahrami, A., Mahdavi, M. Personalized virtual university: Applying personalization in virtual university. 2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC), IEEE, 2011, 6704–6706. https://doi.org/10.1109/AIMSEC.2011.6011232
[11] Kavanagh, S., Luxton-Reilly, A., Wuensche, B., Plimmer, B. A systematic review of virtual reality in education. Themes in Science and Technology Education, 2017, 10(2), 85–119. https://www.learntechlib.org/p/182115/
[12] Freina, L., Ott, M. A literature review on immersive virtual reality in education: State of the art and perspectives. The International Scientific Conference Elearning and Software for Education, 2015, 1, 10–1007. https://www.itd.cnr.it/download/eLSE%202015%20Freina%20Ott%20Paper.pdf
[13] Elmqaddem, N. Augmented reality and virtual reality in education. Myth or reality? International Journal of Emerging Technologies in Learning, 2019, 14(3), 234–242. https://www.learntechlib.org/p/208430/; https://doi.org/10.3991/ijet.v14i03.9289
[14] Bower, M., DeWitt, D., Lai, J. W. Reasons associated with preservice teachers' intention to use immersive virtual reality in education. British Journal of Education Technology, 2020, 51(6), 2215–2233. https://doi.org/10.1111/bjet.13009
[15] Nooriafshar, M., Williams, R., Maraseni, T. N. The use of virtual reality in education. Proceedings of the 7th American Society of Business and Behavioral Sciences International Conference (ASBBS), American Society of Business and Behavioral Sciences (ASBBS), 2004. https://www.researchgate.net/profile/Tek-Maraseni-2/publication/228724825_The_use_of_virtual_reality_in_education/links/0fcfd50c7b72225ecb000000/The-use-of-virtual-reality-in-education.pdf
[16] Coban, M., Bolat, Y. I., Goksu, I. The potential of immersive virtual reality to enhance learning: A meta-analysis. Educational Research Review, 2022, 100452. https://doi.org/10.1016/j.edurev.2022.100452
[17] Ebben, M., Murphy, J. S. The materiality of the virtual professorial 'self' in pandemic Zoom teaching: A mnemonic ethnographic method. Learning, Media and Technology, 2022, 47(3), 328–340. https://doi.org/10.1080/17439884.2022.2056897
[18] Hu-Au, E., Lee, J. J. Virtual reality in education: A tool for learning in the experience age. International Journal of Innovation in Education, 2017, 4(4), 215–226. https://sipa.sc.edu/about/offices_and_divisions/cte/teaching_resources/docs/virtual_reality_education_tool_learning_experience_age.pdf
[19] Smyrnaiou, Z., Georgakopoulou, E., Sotiriou, S. Promoting a mixed-design model of scientific creativity through digital storytelling—the CCQ model for creativity. International Journal of STEM Education, 2020, 7, 1–22. https://doi.org/10.1186/s40594-020-00223-6

[20] Herwin, H., Shabir, A., Asriadi, A. Learning management system based on virtual reality technology in elementary school. World Journal on Educational Technology: Current Issues, 2022, 14(5), 1506–1517. https://doi.org/10.18844/wjet.v14i5.7922

[21] Pantelidis, V. S. Reasons to use virtual reality in education and training courses and a model to determine when to use virtual reality. Themes in Science and Technology Education, 2010, 2(1–2), 59–70. http://earthlab.uoi.gr/ojs/theste/index.php/theste/article/view/22

[22] Isha, V., Japar, M., Maksum, A., Siregar, Y. E. Y., Setiawan, B., Andayani, A. Increasing students' culture literate using virtual reality field trip model: Need analysis. Cypriot Journal of Education Science, 2022, 17(9), 3263–3276. https://doi.org/10.18844/cjes.v17i9.8002

[23] Al Farsi, G., Yusof, A. bin M., Romli, A., Tawafak, R. M., Malik, S. I., Jabbar, J., Rsuli, M. E. B. A review of virtual reality applications in an educational domain. International Journal of Interactive Mobile Technologies (iJIM), 2021, 15(22), 99–110. https://doi.org/10.3991/ijim.v15i22.25003

[24] Astudillo, A., Avella-Rodríguez, E., Arango-Hoyos, G., Ramirez-Scarpetta, J., Rosero, E. Smartphone-based wearable gait monitoring system using wireless inertial sensors. International Journal of Online and Biomedical Engineering (iJOE), 2023, 19(08), 38–55. https://doi.org/10.3991/ijoe.v19i08.38781

[25] Boettcher, K., Behr, A. Using virtual reality for teaching the derivation of conservation laws in fluid mechanics. International Journal of Engineering Pedagogy (iJEP), 2021, 11(4), 42–57. https://doi.org/10.3991/ijep.v11i4.20155

[26] Auld, L. W., Pantelidis, V. S. Exploring virtual reality for classroom use: The virtual reality and education lab at East Carolina University. TechTrends: Linking Research and Practice to Improve Learning, 1994, 39(1), 29–31. https://www.learntechlib.org/p/164615/; https://doi.org/10.1007/BF02763872

[27] McGovern, E., Moreira, G., Luna-Nevarez, C. An application of virtual reality in education: Can this technology enhance the quality of students' learning experience? Journal of Education for Business, 2020, 95(7), 490–496. https://doi.org/10.1080/08832323.2019.1703096

[28] Paszkiewicz, A., Salach, M., Dymora, P., Bolanowski, M., Budzik, G., Kubiak, P. Methodology of implementing virtual reality in education for industry 4.0. Sustainability, 2021, 13(9), 5049. https://doi.org/10.3390/su13095049

[29] Vesisenaho, M., Juntunen, M., Häkkinen, P., Pöysä-Tarhonen, J., Fagerlund, J., Miakush, I., Parviainen, T. Virtual reality in education: Focus on the role of emotions and physiological reactivity. Journal of Virtual Worlds Research, 2019, 12(1). https://doi.org/10.4101/jvwr.v12i1.7329

[30] Chiu, J. L., DeJaegher, C. J., Chao, J. The effects of augmented virtual science laboratories school students' understanding of gas properties. Computers & Education, 2015, 85, 59–73. https://doi.org/10.1016/j.compedu.2015.02.007

[31] Zhou, X., Tang, L., Lin, D., Han, W. Virtual & augmented reality for biological microscope in experiment education. Virtual Reality & Intelligent Hardware, 2020, 2(4), 316–329. https://doi.org/10.1016/j.vrih.2020.07.004

[32] Paxinou, E., Georgiou, M., Kakkos, V., Kalles, D., Galani, L. Achieving educational goals in microscopy education by adopting virtual reality labs on top of face-to-face tutorials. Research in Science & Technological Education, 2022, 40(3), 320–339. https://doi.org/10.1080/02635143.2020.1790513

[33] Papanastasiou, G., Drigas, A., Skianis, C., Lytras, M., Papanastasiou, E. Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first-century skills. Virtual Reality, 2019, 23(4), 425–436. https://doi.org/10.1007/s10055-018-0363-2

[34] Stavroulia, K. E., Ruiz-Harisiou, A., Manouchou, E., Georgiou, K., Sella, F., Lanitis, A. A 3D virtual environment for training teachers to identify bullying. 2016 18th Mediterranean Electrotechnical Conference (MELECON), IEEE, 2016, 1–6. https://doi.org/10.1109/MELCON.2016.7495417

[35] Herga, N. R., Grmek, M. I., Dinevski, D. Virtual laboratory as an element of visualization when teaching chemical contents of science class. Turkish Online Journal of Educational Technology-TOJET, 2014, 13(4), 157–165. https://eric.ed.gov/?id=EJ1043246

[36] Bloomfield, J., Fisher, M. J. Quantitative research design. Journal of the Australasian Rehabilitation Nurses Association, 2019, 22(2), 27–30. https://search.informit.org/doi/abs/10.3316/INFORMIT.738299924514584

[37] Karagozlu, D. Creating a sustainable education environment with augmented reality technology. Sustainability, 2021, 13(11), 5851. https://doi.org/10.3390/su13115851

[38] Antonietti, A., Rasi, C., Imperio, E., Sacco, M. The representation of virtual reality in education. Education and Information Technologies, 2000, 5(4), 317–327. https://doi.org/10.1023/A:1012057608694

[39] Yavuz, E., Uslu, O. Evaluation of social studies teacher candidates' views on the use of virtual reality technology in education. Synergy International Journal of Field Education Research, 2021, 2(2), 132–152. https://doi.org/10.54971/synergy.1011738

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