In technical higher education institutions current state of the use of modern educational virtual reality laboratories in the teaching of specialized sciences

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Abstract. The use of modern virtual reality laboratories in the teaching of specialized subjects in technical higher educational institutions is a rapidly developing field. These simulators provide an immersive and interactive learning experience that allows students to experiment with complex systems in a safe and controlled environment. In this article, the current state of the laboratories used in the teaching of «Basics of Power Supply» in 16 technical higher education institutions selected for research was analyzed, and the advantages and disadvantages of using modern virtual reality laboratories in this case were considered.

1 Introduction

One of the main advantages of using virtual reality simulators in technical education is the ability to provide students with hands-on experiences with equipment and systems that may be difficult or impossible in the classroom [1, 2]. For example, in fields such as energy, students can use virtual simulators to design and test complex processes and systems in industrial plants, allowing them to gain a deeper understanding of the situation and develop the skills and knowledge needed to work with these systems in real-world settings [1, 4, 6].

2 The state of the problem today

Despite these advantages, there are some challenges associated with using virtual reality simulators in technical education. One of the main challenges is the cost and complexity of developing and maintaining simulators, as well as the need for specialized hardware and software [2, 3, 5, 7-10, 12]. In addition, in order to effectively use these simulators in the classroom, it is necessary to develop the skills of using special virtual laboratories for teachers and students [11, 13, 16-19, 14].

The laboratory is performed in 4 different ways:

1. Immersive - through exposure;

2. Physical - performing while standing in front of the device;

3. Observation - research by observation of processes;

4. Virtual - execution using a specific tool.

Today there are 4 types of laboratories (fig. 1) [15, 20]:

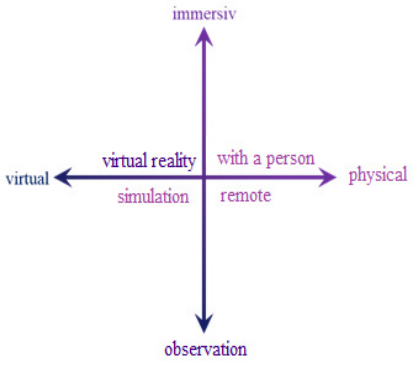

Fig. 1. Grouping of existing laboratories today

1. Traditional laboratories - they are located in physical conditions, in which the student performing the laboratory work is in a real environment [16, 11].

2. Simulations - these are interactive laboratories on a specific computer or other gadget screen, in which students perform some or all of their activities. In this, the user observes the activity through a digital lens.

3. Remote Control – In this the experiments are controlled remotely and the results are observed through digital means to see what happens as a result of the manipulation.

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4. Virtual reality - when the user uses VR glasses, he performs the laboratory while standing in a real environment.

3 A modern solution to the problem

For the research, 16 higher education institutions in Uzbekistan, where the subject «Basics of electricity supply» is taught, were taken. There are 7 laboratory classes in this «Fundamentals of Power Supply» subject, and only conventional type of laboratories are used in all higher education institutions studied. The laboratories conducted in the field of «Electrical supply» require the student to simultaneously develop the ability to feel physically and work on laboratory equipment. And this demand can be met by using the laboratories that are performed only with a traditional person on a laboratory stand, or by using laboratories that perform virtual reality laboratories. Simulators do not fully cover the need, and these types of laboratories are common today, and during our research, we witnessed that these types of laboratories are available in almost all technical higher education institutions. There is no need for remote-controlled laboratories in this discipline [21, 23, 7].

The current situation in selected higher education institutions, that is, the number of existing laboratories, as well as the need for laboratories, was studied and the situation is presented in Table 1.

The analysis of the situation shown in Table 1 shows that today the need for laboratory equipment is very high, and the level of laboratory supply is on average 68% in all technical higher education institutions (Figure 2).

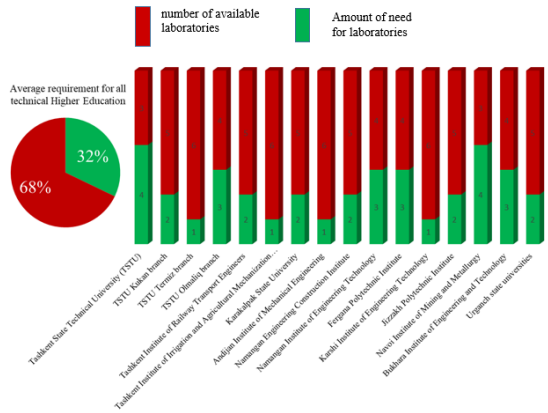

Fig. 2. Diagram of the need for laboratories «Basics of power supply» in technical higher education institutions

Table 1. The level of provision of the «Basics of Power Supply» laboratory in technical higher education institutions

№	Higher educational institution	Course of Study	Traditional laboratories available	The need for a laboratory stand
1	Tashkent State Technical University (TSTU)	5310100 5310200 5310700 5312400	4	3
2	TSTU Kukan branch	5310700	2	5
3	TSTU Termiz branch	5310200 5310700	1	6
4	TSTU Olmaliq branch		3	4
5	Tashkent Institute of Railway Transport Engineers	5310200 5310700	2	5
6	Tashkent Institute of Irrigation and Agricultural Mechanization Engineers	5430500	1	6
7	Karakalpak State University	5310100 5310200 5310700	2	5
8	Andijan Institute of Mechanical Engineering	5310200 5310700 5312400	1	6
9	Namangan Engineering Construction Institute	5310200 5312400	2	5
10	Namangan Institute of Engineering Technology	5310100 5310200	3	4
11	Fergana Polytechnic Institute	5310100 5310200	3	4
12	Karshi Institute of Engineering Technology	5310200 5310700 5312400	1	6
13	Jizzakh Polytechnic Institute	5310100 5310200 5310700	2	5
14	Navoi Institute of Mining and Metallurgy	5310100 5310200	4	3
15	Bukhara Institute of Engineering and Technology	5310100 5310700	3	4
16	Urganch state universities	5310700	2	5

The cost of having 2 different types of laboratories required to meet this need was analyzed and the results were recorded in Table 2. In order to simplify the calculations, the cost of purchasing, bringing and installing the stand of traditional laboratories was set at 100 million UZS based on the current situation. Costs to be allocated for virtual reality labs are assumed to be used by 14 students. In this case, 7 laboratories will be prepared, and two students will be allocated to each virtual laboratory to perform the laboratory (one student will be the manager, and the other student will perform the laboratory) (table 2) [22, 24, 8]:

a. The average cost of a core i5 computer to use a virtual reality laboratory: - 7 million UZS;

b. Average price of virtual reality glasses: 15 million;

c. The cost of purchasing a virtual reality laboratory: 2.5 million soums for 1 laboratory.

d. Installation costs of virtual reality laboratories: 1 mln.

When making these calculations, it is necessary to take into account that it is not necessary to allocate funds only for Virtual Reality glasses and a laboratory, since all the considered technical equipment for Virtual Reality is available in higher education institutions. In table 2, the total costs (column «General» of table 2) in the case where these conditions are taken into account, and the costs allocated in the case of using the current potential at the University (column «In the case of using the existing potential» of table 2) were calculated.

The analysis of table 2 shows that the average cost for each higher education institution is 475 million soums for the acquisition of traditional laboratory stands, 167.5 million soums for virtual laboratories, and 117.5 million soums for using the existing potential of universities. is soum. In addition, up to 4 students can work at the same time in traditional stands. Using virtual reality labs is 14.2 times more effective if two students per booth are calculated, and another advantage of using virtual reality labs is that the wear rate of devices is very small compared to other devices [9, 3, 7].

Table 2. Costs to be allocated to meet the need for the «Basics of Power Supply» laboratory in technical higher education institutions (in million UZS) [25]

№	Higher educational institution	For traditional laboratories (UZS)	For virtual reality labs	
			General	In the case where the existing potential is used
1	Tashkent State Technical University (TSTU)	300	162,5	112,5
2	TSTU Kukan branch	500	167,5	117,5
3	TSTU Termiz branch	600	170	120
4	TSTU Olmaliq branch	400	165	115
5	Tashkent Institute of Railway Transport Engineers	500	167,5	117,5
6	Tashkent Institute of Irrigation and Agricultural Mechanization Engineers	600	170	120
7	Karakalpak State University	500	167,5	117,5
8	Andijan Institute of Mechanical Engineering	600	170	120
9	Namangan Engineering Construction Institute	500	167,5	117,5
10	Namangan Institute of Engineering Technology	400	165	115
11	Fergana Polytechnic Institute	400	165	115
12	Karshi Institute of Engineering Technology	600	170	120
13	Jizzakh Polytechnic Institute	500	167,5	117,5
14	Navoi Institute of Mining and Metallurgy	300	162,5	112,5
15	Bukhara Institute of Engineering and Technology	400	165	115
16	Urganch state universities	500	167,5	117,5

4 Conclusion

In conclusion, it can be said that in the teaching of specialized subjects in technical higher education, traditional stands are used today, but there are also shortcomings in the stands. Addressing this need using modern virtual reality laboratories is both economically and socially effective. Using state-of-the-art virtual reality labs provides students with a powerful and immersive learning experience, allowing them to experiment with complex systems in a safe and controlled environment. From an economic point of view, the introduction of virtual laboratories compared to traditional laboratories is 14.2 times more profitable for the 16 higher education institutions that we examined during our research. In addition, all you need to do is pay for the virtual lab software to create virtual reality science labs from a virtual lab room.

References

1. Venikov V.A., Venikov G.V. The theory of similarity and modeling (in relation to the problems of the electric power industry). - M.: Higher school, 1984, 439 pp.
2. Nikiforov G.V., Oleinikov V.K., Zaslavets B.I. Energy saving and energy management in metallurgical production. M: Energoatomizdat, 2003.- 480 p.
3. Novikov SS Methods of operational planning and control of power consumption of large-capacity electric steel-smelting furnaces when operating on the wholesale electricity market: Avtorefer. dis. ... Cand. those. sciences. - M., 2008.- 18 p.
4. Bazara M., Shetty K. Nonlinear programming. Theory and algorithms. - Moscow: Publishing house: "Mir", 1982. - 583 p.
5. Rakhmonov I.U., Najimova A.M., and Reymov K.M. AIP Conference Proceedings **2647.** 030010. (2022). https://doi.org/10.1063/5.0104788
6. Rakhmonov I.U., Najimova A.M. AIP Conference Proceedings **2647.** 030011. (2022). https://doi.org/10.1063/5.0104791
7. Melikuziev M.V. AIP Conference Proceedings **2552.** (2023). 050021. https://doi.org/10.1063/5.0112395
8. Rasulov A.N., Usmonov E.G., Melikuziev M.V. AIP Conference Proceedings **2552.** (2023). 050018. https://doi.org/10.1063/5.0111530
9. Saidkhodjaev A.G. AIP Conference Proceedings **2552**. 050026. (2023). https://doi.org/10.1063/5.0111540
10. Rakhmonov I.U., Najimova, A.M., Esemuratova Sh.M., Koptileuov T.T. AIP Conference Proceedings **2647.** 070024. (2022). https://doi.org/10.1063/5.0104793
11. Hoshimov F.A., Rakhmonov I.U., Niyozov N.N., Omonov F.B. AIP Conference Proceedings **2647.** 030025. (2023). https://doi.org/10.1063/5.0112388
12. Rakhmonov I.U., Hoshimov F.A., Kurbonov N.N., Jalilova D.A. AIP Conference Proceedings **2647.** 050022. (2023). https://doi.org/10.1063/5.0112391
13. Rakhmonov I.U., Ushakov V.Ya., Niyozov N.N., Kurbonov N.N., Mamutov M. E3S Web of Conferences **289.** 07014. (2021). https://doi.org/10.1051/e3sconf/202128907014
14. Rakhmonov I.U., Ushakov V.Ya., Najimova A.M., Jalilova D.A., Omonov F.B. E3S Web of Conferences **289.** 07013. (2021). https://doi.org/10.1051/e3sconf/202128907013
15. A.D.Taslimov, A.S.Berdishev, F.M.Rakhimov, Melikuziev M.V. E3S Web Conf. **Vol. 139**. 2019. https://doi.org/10.1051/e3sconf/201913901081.
16. R.Karimov. AIP Conference Proceedings 2552. 030014. (2022). https://doi.org/10.1063/5.0111533
17. R.Karimov. AIP Conference Proceedings 2552. 050012. (2022). https://doi.org/10.1063/5.0111524
18. Rakhmonov,I., Berdishev,A., Khusanov, B.M, Khaliknazarov, U., Utegenov, U. IOP Conference Series: Materials Science and Engineering **883(1)**. 012104. DOI 10.1088/1757-899X/883/1/012104
19. I.U. Rakhmonov, T.H. Khakimov, I.I. Bakhadirov, B.M. Khusanov. International Journal of Advanced Science and Technology **Vol. 29**. (2020). pp. 1525-1533.
20. Erejepov, M., Novikov, A.N., Khusanov, B.M., Seytmuratov, B., Sayimbetov, Z. E3S Web of Conferences. **289.** (2021). 07018. https://doi.org/10.1051/e3sconf/202128907018
21. Usmanov E.G., Khusanov B.M. RSES 2020. E3S Web of Conferences **216.** 01161. (2020). https://doi.org/10.1051/e3sconf/202021601161
22. Stilinović, Emma. (2017). Facilitating empathy through virtual reality. Motivation and Emotion **41**. 10.1007/s11031-017-9641-7.
23. https://michaelseery.com/describing-different-types-of-virtual-labs/
24. I.U.Rakhmonov, K.M.Reymov. Statistical models of renewable energy intermittency // RSES 2020. E3S Web of Conferences **216.** 01167. (2020). https://doi.org/10.1051/e3sconf/202021601167
25. I.U.Rakhmonov, F.A.Hoshimov. Development of an algorithm for evaluating the dominant factors that have the greatest impact on the energy intensity of products // ENERGY-21. E3S Web of Conferences. 209 (2020) 07018. doi.org/10.1051/e3sconf/202020907018