

A Systematic Literature Review on Virtual Reality for Learning

Candra Kurniawan, Yusep Rosmansyah,
Budiman Dabarsyah
*School of Electrical Engineering and Informatics
Institut Teknologi Bandung
Bandung, Indonesia
candrak@students.itb.ac.id,
yusep@stei.itb.ac.id, budiman@stei.itb.ac.id*

Abstract—Learning can be performed in various ways and can utilize different technologies. This paper presents a review of current and previous research to understand the use of virtual reality technology for learning. This paper used a systematic literature review (SLR) as a method. Research question (RQ) was determined in the first step. The query for searching the previous research on popular database journals was generated from previously created RQ. Popular journals included IEEE Xplore, ScienceDirect, SpringerLink, Scopus, and ACM Digital Library. Thirty-two related articles were produced from the search, then reviewed. The study concluded that there were four purposes of using virtual reality for learning, two types of devices used, and two types of user experiences.

Keywords—*virtual reality, learning, systematic literature review*

I. INTRODUCTION

In education, learning is the interaction process between learner or participants with educators using some resources in an environment to get knowledge. Learner or participant can be anyone who wants to get knowledge. Educator also can be anyone who has the knowledge to be shared. Resource in learning can be anything, based on what the subject is learned. Knowledge from learning can be new knowledge or enhanced knowledge.

There are many methods used in learning. The classical method or traditional class method is commonly used in learning. Learning activities are carried out in the classroom facilitated by an educator using some resources such as books, presentation slides, and videos. E-learning, using computer and internet technology, is one of the methods offered in learning to improve participants' performance. E-learning offers learning that is time or location limitless. E-learning also can accommodate various strategies and methods of delivering learning. Discussion, problem-based learning, test-based learning, mobile-based learning, game-based learning, and still many other methods can be used in learning.

Various technologies, such as videos, augmented reality, and virtual reality, are being used in learning. Video can present a 2D visual experience for participants. Augmented reality is a technology that combines two-dimensional or three-dimensional virtual objects into a real three-dimensional environment. Virtual Reality (VR) is a technology to simulate the real world into the virtual world using virtual 3D graphics and real-time motion detection [1]. Virtual reality can simulate the interactive environments that can improve the experience [2].

VR's ability to simulate something that is difficult to be presented directly in the real world makes VR widely applied in various sectors. In the military sector [3], VR can simulate a war situation, so the soldiers can feel the battlefield sensation that similar to the real battlefield. In the health sector [4], VR presents a practical experience for participants in the childbirth process. In the education sector [5], educators can do foreign language teaching with 3D media and participants can easily understand the material taught based on the visualization displayed in the VR environment.

Many aspects of virtual reality can be studied in its use for learning, such as features, devices, learning approach, and purposes of using virtual reality in learning. As a result, a literature review is needed to get a deeper understanding of virtual reality for learning. Systematic literature review (SLR) becomes a standard method to obtain the answer that is relevant to the research topic by performing a literature review based on the previous relevant studies. The study using several popular database journals has been carried out to get a comprehensive result.

This paper is divided into several sections. Section 2 discusses the systematic literature review as a research methodology. Section 3 discusses the result. The conclusion is given in section 4.

II. RESEARCH METHODOLOGY

A. Systematic Literature Review

Systematic Literature Review (SLR) is a secondary study to map, identify, critically evaluate, consolidate, and collect the results of relevant primary studies on a certain research topic. SLR becomes a standard method to obtain an answer by performing a literature review based on the previous relevant studies. The purpose of performing SLR is to summarize the previous research, to identify the gap which is needed to be fulfilled between the previous and the current research, to produce a coherent report/synthesis, and to make a research framework.

The purpose of a literature study on this research is to further understand the purpose, device, and user experience on virtual reality for learning. To obtain a comprehensive result, the study undertakes the research on several published literature from popular database journal e.g. IEEE Xplore, ScienceDirect, SpringerLink, Scopus, and ACM Digital Library.

SLR is a process to identify, evaluate, and interpret the research results to answer the determined research question. SLR consists of several stages, namely determining the research question, selecting the corresponding research,

mining the required data, analyzing and describing the discovery.

B. Research Question

The purpose of the research question is to maintain the focus of the literature review. This condition leads to more convenient mining process for the required data. Table I shows the research questions for this research.

TABLE I. RESEARCH QUESTION

ID	Research Question	Motivation
RQ1	What are the purposes of using virtual reality in learning?	To identify the purposes of virtual reality in learning
RQ2	Which virtual reality devices are used in learning?	To identify the virtual reality devices in learning
RQ3	What is the type of virtual reality user experience in learning?	To identify the type of user experience in virtual reality for learning

C. Result Finding

To answer the above research questions, the study conducted a search on the published research paper in the popular database journal with a specific string for searching. The string is “virtual reality” AND (learning OR education OR training). Table II shows the results of the search.

TABLE II. SEARCH RESULT OF EACH DATABASE JOURNAL

No	Database Journal	Number of Articles
1	IEEE Xplore	417
2	ScienceDirect	85
3	SpringerLink	359
4	Scopus	2 267
5	ACM Digital Library	1 130
Total		4 258

The study applied several inclusion and exclusion criteria to filter the article for further exploration. Table III shows the criteria.

TABLE III. INCLUSION AND EXCLUSION CRITERIA

Criteria		
Inclusion	I1	Articles related to purposes of using virtual reality in learning, devices used, and type of user experience.
	I2	Articles published from 2014 to 2019.
	I3	Articles are written in English.
	I4	Full-text articles.
Exclusion	E1	Similar articles from different database journal
	E2	Articles not related to virtual reality and learning.
	E3	Survey articles or literature review articles about virtual reality for learning.

Criteria E1 applied in the first filtering to reduce the number of papers. The second filtering, criteria I2, I3, and I4 applied. The third filtering, criteria E2 and E3 applied. The last filtering, criteria I1 applied to full-text review makes the number of papers to 32. After applying the above inclusion and exclusion criteria, several articles, which published in periodic journal or conference proceeding, satisfy the criteria

and can be utilized as the main reference for SLR. Table IV shows the result of the filtering process.

TABLE IV. NUMBER OF ARTICLE AFTER FILTERING PROCESS

Index	Publication Media	Article Found
1	Q1 Journal	5
2	Q2 Journal	9
3	Q3 Journal	3
5	Conference Proceeding	15
Total		32

III. RESEARCH RESULT

A. Purpose of Virtual Reality in Learning

Based on the literature review, there are four purposes of using virtual reality in learning as shown in Table V. Engaging the participants related to how to make participants more interested in the learning material provided. VR provides a virtual world that is made similar to the real world, places that are in real words difficult to reach, objects that are no longer found such as historical objects [6], even places that don't exist in the real world. Participants who use VR technology in their learning will be more interested than having to read a book, search the internet site, and directly go to places that need a lot of time to get there.

Motivating the participants relates to how VR can provide indirect support to participants from the environment created. VR is designed to provide motivation to participants who take stroke rehabilitation by providing virtual physical games [7]. The game is designed so that participants can do physical movements that are useful in therapy. Participants will be more motivated by VR, and therapists will be easier to do their jobs

Enhancing the learning experience is related to how VR can overcome learning problems that cannot be solved with classical learning. This purpose is the most commonly used purpose in the use of VR technology for learning. Gynecological experience can be obtained with VR without having to fear the risk of errors affecting patients [4]. Participants who are separated from distances can also be collected together in a 3D environment by building a virtual world and connecting it with VR devices [19]. The last purpose is improving participants' achievement, that purpose is related to how the application of VR technology has implications for learning outcomes.

TABLE V. LIST OF PURPOSE USING VIRTUAL REALITY IN LEARNING

No	Purpose	References
1	Engaging the participants	[8] [9] [10] [6] [11]
2	Motivating the participants	[12] [13] [14] [8] [10] [15] [7] [16] [17]
3	Enhancing the learning experience	[4] [3] [5] [18] [19] [2] [20] [21] [22] [23] [24] [25] [26] [27] [28]
4	Improving participants' achievement	[15] [29] [22] [30] [31] [25] [1] [32]

B. Virtual Reality Devices in Learning

Some devices are used in VR technology for learning. This device functions to achieve the experience of immersion. Table VI shows two types of devices differentiated by the function, projection, and interaction.

Projections relate to the sense of sight, while interactions relate to other senses such as hearing and touching.

Projection is divided into 2 types of devices, they are large screen and personal screen. Examples of the large screen are a projector, 3D monitor, and 3D TV. The personal screen that is commonly used is the head mounted device (HMD). Popular HMD used are HTC Vive, Google Cardboard, Oculus Rift, and Samsung VR.

Interaction consists of 3 devices, they are tracking devices, haptic devices, and audio devices. Tracking devices such as gloves and armbands. Haptic devices are joysticks and stylus. The audio device is a 3D sound system.

TABLE VI. VIRTUAL REALITY DEVICES

No	Device	Type	References
1	Projection	Personal Screen	[4] [13] [3] [5] [14] [18] [15] [6] [21] [29] [11] [22] [23] [24] [31] [25] [26] [27]
		Large Screen	[20]
2	Interaction	Tracking	[12] [3] [7] [17] [26]
		Haptic	[4] [3] [14] [20] [16] [28]
		Audio	[3]

C. Type of Virtual Reality User Experience in Learning

The user experience offered in virtual reality consists of 2 types, they are single user and multi user as shown in Table VII. Single user offers experience in the virtual world individually. Participants interact with entities in the VR environment without involving other users. Multi user offers experience in the virtual world in a team. Participants can interact with entities in the VR environment and with other users.

TABLE VII. USER EXPERIENCE

No	Type	References
1	Single User	[4] [13] [5] [10] [6] [7] [2] [20] [21] [29] [22] [23] [24] [17] [31] [25] [26] [1] [27] [28] [32]
2	Multi User	[12] [3] [18] [19] [16] [11] [30]

IV. CONCLUSION

The study finds three aspects of using virtual reality technology for learning, they are purposes, devices, and user experience. Four purposes why using virtual reality technology for learning are engaging the participants, motivating the participants, enhancing the learning experience, and improving participants achieve. The most purpose used is enhancing the learning experience. Two types of devices differentiated by the function are used by VR for learning, they are projection and interaction. The most device used in projection function is personal screen or commonly called HMD, and for interaction is a haptic device such as a joystick. The user experience offered by VR in learning consists of two types, they are single user and multi user. The most user experience used is single user.

REFERENCES

[1] S. F. Ali, S. Noor, S. A. Azmat, A. U. Noor, and H. Siddiqui, "Virtual reality as a physical training assistant," in *2017 International Conference on Information and Communication Technologies (ICICT)*, 2017, pp. 191–196.

[2] P. N. A. Barata, M. R. Filho, and M. V. A. Nunes, "Consolidating

Learning in Power Systems: Virtual Reality Applied to the Study of the Operation of Electric Power Transformers," *IEEE Trans. Educ.*, vol. 58, no. 4, pp. 255–261, Nov. 2015.

[3] Y.-C. Fan and C.-Y. Wen, "A Virtual Reality Soldier Simulator with Body Area Networks for Team Training," *Sensors (Basel)*, vol. 19, no. 3, 2019.

[4] C. Chang, S. Yeh, M. Li, and E. Yao, "The Introduction of a Novel Virtual Reality Training System for Gynecology Learning and Its User Experience Research," *IEEE Access*, vol. 7, pp. 43637–43653, 2019.

[5] Y. Xie, L. Ryder, and Y. Chen, "Using Interactive Virtual Reality Tools in an Advanced Chinese Language Class: a Case Study," *TechTrends*, May 2019.

[6] C. Donghui, L. Guanfa, Z. Wensheng, L. Qiyuan, B. Shuping, and L. Xiaokang, "Virtual reality technology applied in digitalization of cultural heritage," *Cluster Comput.*, May 2017.

[7] D. Levac et al., "A knowledge translation intervention to enhance clinical application of a virtual reality system in stroke rehabilitation," *BMC Health Serv. Res.*, vol. 16, no. 1, p. 557, Apr. 2016.

[8] S. F. M. Alfalah, "Perceptions toward adopting virtual reality as a teaching aid in information technology," *Educ. Inf. Technol.*, vol. 23, no. 6, pp. 2633–2653, Nov. 2018.

[9] M. Yang, "Application of Virtual Reality Technology in College Students' Mental Health Education," in *Journal of Physics: Conference Series*, 2018, vol. 1087, no. 6.

[10] G. T. A. Kusuma, I. M. A. Wirawan, and I. K. R. Arthana, "Virtual reality for learning fish types in kindergarten," *Int. J. Interact. Mob. Technol.*, vol. 12, no. 8, pp. 41–51, 2018.

[11] C. Vazquez, L. Xia, T. Aikawa, and P. Maes, "Words in motion: Kinesthetic language learning in virtual reality," in *Proceedings - IEEE 18th International Conference on Advanced Learning Technologies, ICALT 2018*, 2018, pp. 272–276.

[12] S. Arlati et al., "A social virtual reality-based application for the physical and cognitive training of the elderly at home," *Sensors (Switzerland)*, vol. 19, no. 2, 2019.

[13] W. Tarnq, C.-J. Chen, C.-Y. Lee, C.-M. Lin, and Y.-J. Lin, "Application of virtual reality for learning the material properties of shape memory alloys," *Appl. Sci.*, vol. 9, no. 3, 2019.

[14] A. Bhargava, J. W. Bertrand, A. K. Gramopadhye, K. C. Madathil, and S. V. Babu, "Evaluating multiple levels of an interaction fidelity continuum on performance and learning in near-field training simulations," *IEEE Trans. Vis. Comput. Graph.*, vol. 24, no. 4, pp. 1418–1427, 2018.

[15] N. S. Schutte and E. J. Stilinović, "Facilitating empathy through virtual reality," *Motiv. Emot.*, vol. 41, no. 6, pp. 708–712, May 2017.

[16] P. Khanal et al., "Collaborative virtual reality based advanced cardiac life support training simulator using virtual reality principles," *J. Biomed. Inform.*, vol. 51, pp. 49–59, 2014.

[17] S. Yoo, P. Gough, and J. Kay, "VRfit: An Interactive Dashboard for Visualising of Virtual Reality Exercise and Daily Step Data," in *Proceedings of the 30th Australian Conference on Computer-Human Interaction*, 2018, pp. 229–233.

[18] T.-H. Wu, F. Wu, C.-J. Liang, Y.-F. Li, C.-M. Tseng, and S.-C. Kang, "A virtual reality tool for training in global engineering collaboration," *Univ. Access Inf. Soc.*, pp. 1–13, 2017.

[19] X.-Q. Chang, D.-H. Zhang, and X.-X. Jin, "Application of virtual reality technology in distance learning," *Int. J. Emerg. Technol. Learn.*, vol. 11, no. 11, pp. 76–79, 2016.

[20] Z. Wang, Y. Ni, Y. Zhang, X. Jin, Q. Xia, and H. Wang, "Laparoscopic varicocelectomy: Virtual reality training and learning curve," *J. Soc. Laparosc. Surg.*, vol. 18, no. 3, 2014.

[21] I. Giangreco et al., "VIRTUE: A Virtual Reality Museum Experience," in *Proceedings of the 24th International Conference on Intelligent User Interfaces: Companion*, 2019, pp. 119–120.

[22] K. Szezurowski and M. Smith, "'Woodlands' - a Virtual Reality Serious Game Supporting Learning of Practical Road Safety Skills," in *2018 IEEE Games, Entertainment, Media Conference (GEM)*, 2018, pp. 1–9.

[23] G. Schofield et al., "Viking VR: Designing a Virtual Reality Experience for a Museum," in *Proceedings of the 2018 Designing Interactive Systems Conference*, 2018, pp. 805–815.

[24] D. Goedicke, J. Li, V. Evers, and W. Ju, "VR-OOM: Virtual Reality On-Road Driving Simulation," in *Proceedings of the 2018 CHI*

- Conference on Human Factors in Computing Systems, 2018, pp. 165:1--165:11.
- [25] K. Zhang, J. Suo, J. Chen, X. Liu, and L. Gao, "Design and implementation of fire safety education system on campus based on virtual reality technology," in 2017 Federated Conference on Computer Science and Information Systems (FedCSIS), 2017, pp. 1297-1300.
- [26] L. Ying, Z. Jiong, S. Wei, W. Jingchun, and G. Xiaopeng, "VREX: Virtual reality education expansion could help to improve the class experience (VREX platform and community for VR based education)," in 2017 IEEE Frontiers in Education Conference (FIE), 2017, pp. 1-5.
- [27] P. Vichitvejpaisal, N. Yamee, and P. Marsertsri, "Firefighting simulation on virtual reality platform," in 2016 13th International Joint Conference on Computer Science and Software Engineering (JCSSE), 2016, pp. 1-5.
- [28] A. Gamlin, P. Breedon, and B. Medjdoub, "Immersive Virtual Reality Deployment in a Lean Manufacturing Environment," in 2014 International Conference on Interactive Technologies and Games, 2014, pp. 51-58.
- [29] P. Hajeswaran, N. Hung, T. Kesavadas, J. Vozenilek, and P. Kumar, "AirwayVR: Learning Endotracheal Intubation in Virtual Reality," in 2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), 2018, pp. 669-670.
- [30] J. Molka-Danielsen, E. Prasolova-FØrland, M. Fominykh, and K. Lamb, "Use of a Collaborative Virtual Reality Simulation for Multi-Professional Training in Emergency Management Communications," in 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), 2018, pp. 408-415.
- [31] T. Blome, A. Diefenbach, S. Rudolph, K. Bucher, and S. von Mammen, "VRanimate — Non-verbal guidance and learning in virtual reality," in 2017 9th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games), 2017, pp. 23-30.
- [32] G. Jin and S. Nakayama, "Virtual reality game for safety education," in 2014 International Conference on Audio, Language and Image Processing, 2014, pp. 95-100.